DOCUMENT RESUME

ED 080 248 RC 007 168

AUTHOR	Moore, William M., Ed.; And Others
TITLE	Nutrition, Growth and Development of North American Indian Children. Monograph.
INSTITUTION	National Institutes of Health (DHEW), Bethesda, Md.
REPORT NO	DHEW-Pub-NIH-72-26
PUB DATE	72
NOTE	247p.
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 ($1.25, paper cover)
EDRS PRICE	MF-$0.65 HC-$9.87
DESCRIPTORS	*American Indians; Behavior; *Child Development; Culture; Dietetics; Eskimos; *Growth Patterns; *Health; History; Nonreservation American Indians; *Nutrition; Reservations (Indian); Social Influences; Social Stratification

ABSTRACT

Recognizing the special health needs of disadvantaged minority groups, in May 1969 the National Institute of Child Health and Human Development cosponsored a conference on these needs for North American Indian children. The monograph, based on this conference, summarizes previous knowledge, provides new information, and emphasizes the role of nutrition during growth and development. Articles are in 6 parts: (1) Perspectives in North American Indian Child Health and Development; (2) Diets, Growth and Nutritional Status of North American Indians; (3) Developmental Consequences of Malnutrition; (4) Field Studies of Malnutrition and Child Development; (5) Cultural Stability and Social Change in North American Indians; and (6) Nutrition Research and Community Service Among Native American Populations. Subject and author indexes close the document. (KM)

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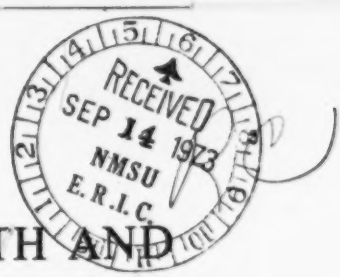

NUTRITION, GROWTH AND DEVELOPMENT OF NORTH AMERICAN INDIAN CHILDREN

Edited By
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Based on a Conference

Cosponsored by the

National Institute of Child Health and Human Development

Indian Health Service

American Academy of Pediatrics Committee on Indian Health

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
National Institutes of Health

DHEW Publication No. (NIH) 72-26

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $1.25 (paper cover)

RC007168

Library of Congress Catalog
Card Number 72-600202

FOREWORD

Recognizing the special health needs of disadvantaged minority groups within our population, the National Institute of Child Health and Human Development was glad to be able to cosponsor the Conference on Nutrition, Growth and Development of North American Indian Children, upon which this monograph is based. The papers and discussions summarize previous knowledge, provide new information, and emphasize the role of nutrition as it interacts with other factors during growth and development. As important as the scientific contributions are the attitudes of the Indian representatives regarding the nutritional and health problems of their people and the attitudes of those who conduct research or provide service in these areas. The dialog among the researchers, clinicians and Indian representatives helped establish a deeper appreciation of human values in studies and programs which advance the understanding of developmental processes and meet the health needs of North American Indians.

We hope this monograph will aid scientists in the fields of nutrition, public health and anthropology, officials responsible for Indian programs, and Indian groups throughout the nation. The National Institute of Child Health and Human Development supports and conducts fundamental research on many of the issues discussed in this monograph and welcomes the opportunity whenever possible to cooperate with other public and private agencies in activities to improve the health and development of North American Indian children.

GERALD D. LAVECK, M.D.
Director
National Institute of Child Health
and Human Development

PREFACE

In May 1969, the National Institute of Child Health and Human Development, the Indian Health Service, and the American Academy of Pediatrics Committee on Indian Health cosponsored a Conference on Nutrition, Growth and Development of North American Indian Children. The conference emphasized the broad range of environmental and cultural factors which affect the health and development of Indian children. Particular attention was devoted to Indian diets and nutritional status and to the potential consequences of malnutrition. Studies were reported from the United States and abroad to expand the limited body of information on the nutrition of North American Indians and to help solve some of the theoretical and practical problems of understanding, correcting and preventing malnutrition.

Representatives of Indian tribes, service personnel, and researchers from the biomedical and social sciences met for three days at the Conference Center of the College for Continuing Education, University of Oklahoma at Norman. Much lively debate occurred both inside and outside of the scheduled sessions. As might be expected, the diverse backgrounds of the participants and the technical nature of some of the presentations led to an unevenness of understanding as well as differences of opinion regarding the relevance or significance of particular statements. Shifts were made in the agenda to permit extended discussion of controversial matters. The Indian representatives were encouraged to present their views and did so eloquently and convincingly. Candid comments from most participants resulted in a better appreciation of the role of nutrition in human development, including how the effects of malnutrition might be studied, prevented and treated within Indian communities.

While this monograph is based on the Conference on Nutrition, Growth and Development of North American Indian Children, the papers and discussions have been rearranged to give added emphasis to the relationships among the topics. The revised presentations include material from the discussions supplemented by additional information to broaden the usefulness of the monograph which we hope will serve as a basic reference on the subject.

The editors are grateful for the assistance provided by members of the Indian Health Service and the Committee on Indian

Health in the planning and implementation of the conference. We thank the many participants who presented papers or contributed substantially to the discussions. We especially thank the Indian representatives for their straightforward, meaningful, and thought-provoking comments. We hope this book will focus attention on the nutrition and health problems of the children they represent and thereby stimulate constructive action on their behalf.

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M.S.R.

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In addition to the above individuals who served as session chairmen, presented papers, or participated in panel discussions, Tribal Representatives from each of the major Indian Health areas, members of the American Academy of Pediatrics Committee on Indian Health, and Indian Health Service nutritionists and physicians contributed substantially to the conference proceedings.

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I

Perspectives in North American Indian Child Health and Development

Introduction

Merrill S. Read, William M. Moore, and Marjorie M. Silverberg

Heritage of North American Indians

LaDonna Harris

INTRODUCTION

Merrill S. Read, William M. Moore and Marjorie M. Silverberg

National Institute of Child Health and Human Development

The problems of health care for American Indians and Alaska Natives reflect in a microcosm the problems of the entire country, problems which all too often result in a vacuum of health care for many American people.

There is no question that an explosive advance in science and technology in this nation has occurred in the last several decades. Undoubtedly, rapid strides will continue to be made in the future. But if all of the science and technology were to be added together, the sum would be less than the whole. The difference is the human factor--the imperceptible change in human attitudes and performance as conditions improve. People need to understand the significance of research findings as they relate to service programs. Key to this translation is a body of people--specialist and non-specialist alike--who can and are dedicated to providing service to meet human needs.

The fundamental needs of the human being have not changed appreciably since the beginning of recorded history; only the means of expressing and satisfying these needs have changed. As man evolved culturally certain simple structures developed: the formation of families for the care of offspring; association among families to form larger social and protective groups; the establishment of a social order to assure continuity and provide a focal point for individual grievances or for arbitration. These concepts have carried over to modern technological societies, although they frequently are obscured and overlooked. Hunt-

ing for food has been replaced by hunting for a job or striving toward a higher income to better provide food and to meet other needs. Villages have been followed by cities, states, and nations, all with purposes not too different from those underlying the original associations among families. However, as the units have grown and many nuclear families have ceased to be self-sufficient, governments have assumed responsibility for services previously handled by the family units themselves. While many problems have been solved, new and unexpected ones have been simultaneously created. The health and social problems have become particularly acute for those segments of society bypassed in the course of industrialization. They have been unable to share in the general progress because they cannot compete without the skills demanded by a technological society. In addition, the delivery of medical and welfare services does not match their unique dependence upon such services. Poor health and inadequate education have established a vicious cycle of dependency on an inadequate system. To these considerations must be added the geographic and social isolation experienced by Native American groups, further limiting their opportunities and their impact on the consciousness of the majority.

Life for the North American Indian and the Alaska Native, which has been either idealized and romanticized or deprecated in history books and films, is full of reminders that the first Americans face severe hardships and share less in the affluence of modern society than any other group. The average income of an Indian in 1968 was $900 per person (1) compared with a national average of $3,412 (2); this was only 26% of the national average. Unemployment in March 1970 for Indians 16 years and older was 40% (3) compared to a national average of 4.4% (4). Infant mortality among Indians was 32.2/1,000 live births in 1967 (5), considerably higher than the figure of 19.7 for whites in that same year and approximately equal to the figure for all non-white Americans (6). Among teenagers 15 to 19 years old, the average suicide rate for Indians from 1965-67 was 19.2/100,000, almost five times that of the national average of 4.3/100,000 in 1966 (7).

Under conditions such as these, it is not surprising that the nutritional and other developmental problems documented elsewhere in this volume have been identified. It is tragic, however, that such conditions continue to exist. It is vitally important that all Americans increase their awareness and sensitivity to the plight and create the pressure for redress.

The purpose of the conference in Oklahoma was to define the scope and the limits of our knowledge regarding Indian child nutrition and development. The lively discussions stimulated by the Tribal Representatives facilitated a probing analysis of the relationship between research on human development and the need to translate these

findings into action programs to improve the life of the Native American. There was no doubt that research and service in the area of nutrition and health can be closely coordinated to the benefit of both.

We believe that the data and concepts summarized in the following pages will stimulate many who are serving Native Americans. Further, we believe that these papers have much broader implications for programs for all Americans who are presently not receiving adequate health care.

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THE HERITAGE OF NORTH AMERICAN INDIANS

LaDonna Harris
Americans for Indian Opportunity

I am delighted this book has been written for many reasons, mostly because many different professionals have tried to solve a specific problem; I think this kind of attitude will come close to achieving what we hope.

My Comanche cultural background entitles me to one-half enrollment in the tribe and I am considered one-half degree Comanche. Our children are then one-fourth members of the Comanche Tribe. Our oldest daughter is one of those "faded" Indians we are seeing more of. Our youngest daughter, who is 9 years old, is a real Indian. She is very dark, with dark eyes and hair. Our oldest daughter is the only real Indian, unfortunately, in the sense that her cultural background is Indian more than the other two children, who are growing up in Virginia. The Federal government finally decided they would repay the Comanches and Apaches some money they owed them. I think we received about $94 individually as the first payment. We were sitting around the dinner table and Fred asked, "What are we going to do with our Indian money?" Our oldest daughter, the blond-headed, blue-eyed one, said, "Daddy, you are not an Indian." Now he claims he knows how a minority feels.

My mother was a dietician at the Indian Public Health Hospital, and I grew up in the setting of the Indian Health Hospital. Because she worked and lived there--at that time the residence was on the campus of the hospital, I was reared by my grandparents, my Paiute grandfather

and Christian grandmother. I feel I have an interesting background--one that has meant a great deal to me. I think the strength that I have comes from my Indian heritage, because this is the side of the family I identify with. These are the people who gave me strength and encouraged me to be the kind of person I hopefully am now and would like to be. Their continuing interest in me has kept me devoted to and involved with the programs and problems of Indians.

I have been very much involved in the past with the National Council on Indian Opportunity headed by the Vice President and consisting of eight Cabinet officers and eight Indian members. The Council is concerned about off-reservation Indians, which include those from Oklahoma and Alaska and urban Indians. I think the problem of the urban Indian is the most urgent today. In my brief studies--including what we have been able to discover in Oklahoma and the discussions in several national meetings I have held--we found that the transition from rural to urban is as meaningful for Indians as it is for peoples immigrating from other countries. It is more significant because of what happens to the Indian when he gets to the city. He is ill equipped and poorly educated; his attitude towards services and his dependency on the Bureau of Indian Affairs and the Indian Health Service make him unable to understand the complexities of an urban setting.

The findings so far regarding Indians in the urban setting show they are the lowest group socially, economically, and medically. We have said over and over that the national policy should be that of lessening his dependency on the government and learning to use other facilities. I know the pressure on physicians in Oklahoma City from Indians off the reservations who say we need an Indian Health Service Hospital in Oklahoma City, rather than use the facilities that exist and are available to all the citizens. The situation is worse in San Francisco and Los Angeles, particularly when the Indians come off the reservations directly into an urban setting. They are crying out for help--their needs are so great and so desperate. Not knowing what else to do, their voices cry out to the Bureau of Indian Affairs, which is really unable to help in this area, and to the Indian Health Service, which does not know they even exist in many cases. For instance, in Dallas, which I know personally, there were reported to be only 350 Indian families. I know I have more relatives than that in Dallas, so we began to investigate. The Bureau of Indian Affairs, through their relocation program, then stated that close to 7,000 or 8,000 Indian families lived in the city. If you take a closer look--and this is only through the BIA--the number is closer to 10,000 to 12,000 families in Dallas, and Dallas doesn't even know they are there.

Another gross example of the unawareness of this country to the problems of Indians is the invitation I received to attend the National Health Forum in New York, not as an Indian or even a Senator's wife, but as a representative of the Urban Coalition. My attendance there made me the only Indian. Fortunately, our Mexican-American cousins

took over the forum and made the group very much aware of their neglect. The national attitude both of public and private groups, which the National Health Forum represents, is indicated by the fact that there were no Indians there, not even a representative from the Indian Health Service, which appalled me.

The school system, the public health system, even the Office of Economic Opportunity, does not know Indians are there. When the poverty program doesn't know they exist, you know the magnitude of their problems. Federal and local agencies need to know that these people are there and are in desperate need, and direct their attention to meeting their needs, because these people find themselves unable to turn to the responsible agency. And so they feel hostility and anger, which becomes a kind of passive aggression, the term used by Dr. Robert Leon from the University of Texas, who has done a great deal of work on the mental health of Indians and their attitudes. This passive aggressiveness that Indians acquire is expressed as a kind of a quiet, so-called sullen attitude (not even sullen--he will even lower his eyes perhaps when you're talking to him). If these feelings come out destructively, it is because he believes he has no alternative; he doesn't know people out there are available to help him or that help even exists.

Reference is often made to the poor education Indians receive. It's not only education. The education that needs to be done is the education of the agencies that serve them, particularly of the professionals, because pediatricians and others particularly interested in children can make significant contributions towards solving some of these problems.

We fall back on poverty as an explanation for so many problems and the fact that malnutrition accompanies poverty. But what is poverty? Is it really only the lack of money? What brings this all about? And though we are interested in children, the fact is that we must deal with the problem of the whole system. I am very much interested in the problems of mental health, because I think we are going to find different kinds of mental health problems from those we have faced before. I feel that in the studies I am beginning to obtain, there is a pattern of cultural breakdown. The pattern illustrated by my own background, of being reared by grandparents, is disappearing. Perhaps in some communities extended families still exist, but increasingly the older generation isn't available to care for the young. Without grandparents or aunts and uncles to help care for the children, people have no one to depend on. What are the results of this change?

As I mentioned earlier, the Indian is becoming urban. I think that at least half of the Indians are in urban settings now, and if off-reservation Indians are included, more than half actually live in cities. We are becoming as urbanized as the rest of the country. This means a different life pattern, because there is no family to depend on, as I had. If my children had to depend on old patterns, their grandparents wouldn't be there, stable enough to be the kind of substitute parents they would

need. We talk a great deal about the suicide rates among Indian children, particularly young children. I think the philosophy of Indian schools will have to change and the meaning they have in the lives of children today. You cannot really separate nutrition from a child's whole involvement in life and what it means to him. In Oklahoma, one-tenth of the population of Indian children in Indian schools are Oklahoman and the rest are children from the Navajo Reservations and from Alaska. Coming from Alaska to Oklahoma would be as strange as coming from Norway or going to Italy or Africa, and the Indians with distinctly different backgrounds don't identify with the Indians here and the children in the boarding schools. These children are as isolated and segregated from all aspects of the community as they can possibly be.

While there are great improvements in Indian opportunity in Oklahoma, and Indian education at the University of Oklahoma gives them a chance to be involved in their state, I think we have to look at the child as a whole to begin to change his patterns of life. The suicide rate continues to go up--and the figures are only known suicides--so that it is now three times as high in the Indian male as the national average. Highway and other accidents may be part of the so-called victim-precipitated death, where an Indian unconsciously seeks his destruction. Alcoholism is another form of the self-destruction pattern. I get so tired and even angry sometimes at the idea of having an alcohol program for Indians, because it seems the problem is not being approached in proper sequence. The programs are offered after the fact instead of attacking the roots of the problem.

The attitudes and approaches of those serving Indians have to change too. Growing up, I took my grandparents to the Indian Hospital--I couldn't go because my mother worked there, which was one of their policies. Dr. Rabeau has changed some of these policies, but not all of them. Unfortunately, he has left and I hope I will respect his successor as much as I do Dr. Rabeau, who has brought new approaches to solving problems, such as hospital boards with Indian participation, and Indian Health Aides, so that people feel a part of what is going on. But I talked with deans of medical schools, to Dr. Riley at the University of Oklahoma, to individuals at Harvard and other universities about the problem or unlikelihood of Indians going to medical school. I said how improbable it would be for an Indian to plan a medical career, since most have had only very unpleasant experiences in hospitals or have been refused treatment. Dr. Robinson can cite numerous cases of people refused treatment in Oklahoma City. They are told to drive to Claremore, Oklahoma, or a hundred miles to Lawton to the Indian Health Service facility, instead of using the health services in Oklahoma City. When an Indian is refused service or has been told to use the Indian Health Service facility, he is not going to have a positive attitude toward health services or a medical career.

Pride in the Indian heritage is certainly not encouraged by those

who serve the Indian. More than 50% of American products today consist of plants used by Indians before Columbus. Botanists have yet to discover in 400 years any herb that has not been used by Indians. Yet few people know this.

The importance of the approach to the delivery of services and such things as nutrition information can't be overemphasized. I learned about nutrition through my homemaking classes in high school. The course was the dullest, most horrible subject I had, and the only reason I learned was that unfortunately--or perhaps fortunately--for the three years I took it, we had to have a new teacher each year, each having just graduated from college. Nutrition was the only thing we learned because it was the first subject they taught. So we were taught over and over about nutrition. But it was so uninteresting. I can imagine what it would be like to approach an Indian family in the hills of eastern Oklahoma about nutritious foods. What kinds of approaches should be used? I think methods are the most important aspects of programs. All the well meaning people in the world can get together and try to do something, but if their approaches aren't appropriate or attitudes aren't correct, we will not accomplish anything.

I hope that the Indian people represented at the Conference have given you the kind of confrontation to shake you to your grass roots so that you can respond to their feelings and frustrations. I think it will be a healthy thing. Maybe th[illegible]won't be this passive aggressiveness Dr. Leon describes, and may[illegible] will be a healthy aggression and the outcome will be that children [illegible]'t have to go through this again.

I want to compliment this group for the meeting and subsequent book. I'm like the preacher preaching to the converted. But I do want to reinforce your efforts to improve the health and nutrition of Indians.

II

Diets, Growth and Nutritional Status of North American Indians

Changing Dietary Patterns of North American Indians
Nancie L. Gonzalez

Physical Growth of North American Indian and Alaska Native Children
William M. Moore

Contemporary Nutritional Status of North American Indian Children
William K. Carlile, Helen Ger Olson, Jean Gorman, Clayton H. McCracken, Robert VanderWagen, and Hilary Connor

Nutrition Survey of Lower Greasewood, Arizona Navajos
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Nutrition Survey of White Mountain Apache Preschool Children
George M. Owen, Carl E. Nelson, Kathryn M. Kram, and Philip J. Garry

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CHANGING DIETARY PATTERNS OF NORTH AMERICAN INDIANS

Nancie L. Gonzalez
University of New Mexico

Although anthropologists have intensively studied American Indian cultures for the past 100 years, surprisingly little is known about their present nutritional status. Based on information concerning their income, estimated in 1964 to be below $2,000 annually per family, it is believed to be poor. Low income, quite apart from particular beliefs or customs, may account for the nutritional inadequacies found among them. Nevertheless, knowledge of the development of dietary patterns of various Indian cultures within North America may serve as a basis for improving their present diets.

The term North American Indian encompasses a wide variety of groups with distinct cultural patterns. Here I will describe the dietary patterns of several different American Indian cultures before European contact in relation to the ecological zones in which they lived, their means of acquiring and distributing foods, and the nature of the marked changes that occurred after European immigration. Evidence for the dietary patterns comes from archeological finds, early travelers' accounts, and some ethnographies. The latter frequently attempted to reconstruct the past through the analysis of mythology, art, religious ceremonies, and dimly-remembered traditions. The evidence concerning nutritional changes and their effects derives from the same sources as for the diets, with more reliance on ethnography, descriptions by missionaries and medical personnel, and modern dietary studies.

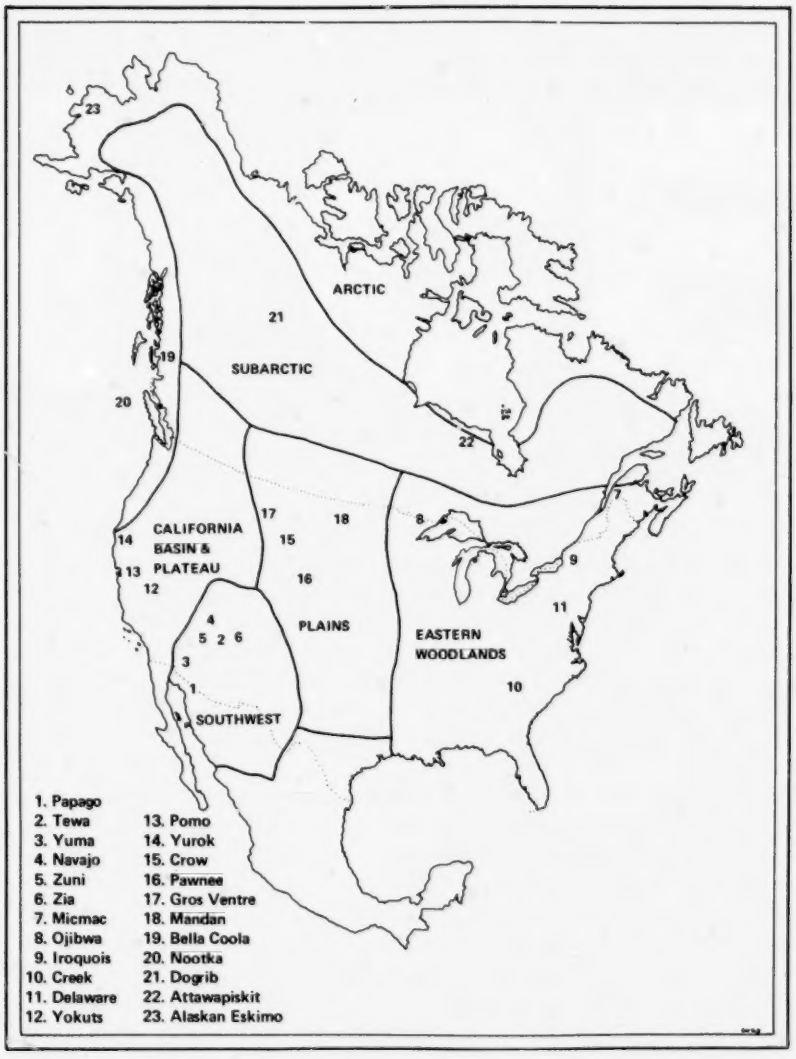

Figure 1: Map of the North American continent showing the location of tribes discussed in text.

The map of North America is divided into several basic geographical areas (Fig. 1), representing different climatic zones having different floral and faunal distributions. The diet of the Indian groups living within each of these zones was affected by the natural potential of the environment. Utilization of the naturally-occurring forms varied somewhat through time, depending on the type of technology available to the Indians. The development of agriculture, the later introduction of the horse and European domesticated animals, and the introduction of guns significantly changed the ways Indians used their environments. However, the extent to which certain basic dietary patterns persisted through time is remarkable in spite of the tendency for white man's food to replace the Indian's, and the general leveling effect of modern civilization upon the aboriginal cultures.

THE ARCHEOLOGICAL RECORD

The beginning of cultural development in the New World is somewhat obscure. Although evidence exists for man's arrival in the Western Hemisphere from Asia via the Bering Strait, the date and the cultural equipment he brought with him are unclear. The evidence for migrations before 12,000 B.C. is scattered. Probably several widely separated waves of migration occurred, bringing in a Paleolithic culture that included stone tools, possibly crude pottery, and the domesticated dog. At that time man was undoubtedly omnivorous, hunting large mammals to be supplemented by a wide variety of plant and animal foods. It is probable that the Paleo-Indians did not experience kwashiorkor or protein malnutrition frequently; indeed, these groups depended heavily on meat. However, all records suggest that the actual food intake varied with the season and the luck and skill of the hunters. Undoubtedly a constant "feast or famine" condition prevailed, and the effects of this fluctuation on the body should be considered in estimating the state of nutrition of these early populations.

Early man, following the game animals, rapidly moved south through the southwestern plains corridor into Mexico and down through South America. Another migration spread eastward into the Subarctic, the upper Great Lakes region, and into the Eastern Woodlands. In time as the availability of game changed, some groups began to concentrate on other kinds of foods and gradually adapted to different diets. For instance, in the California zone acorns formed a substantial dietary staple, whereas in parts of the Southwest the intense collection of wild seeds and other plant products formed the basis for the adoption of agriculture.

Exactly when or where man first began to domesticate plants within the present United States is not known. Archeological records show that the southwestern area demonstrated this pattern first. Most likely, elements of agriculture spread north from Mexico and Central

America, where maize and other foods appear to have been domesticated somewhat earlier. In the upper Great Lakes region, cultivation probably occurred before 1,000 B.C., considerably later than in Mexico and Central America and the southwestern United States. In the upper Great Lakes region the earliest crops differed from those in the more southern areas. They included squash and gourds, the sunflower, and the marsh elder; significantly missing were corn and beans. Corn did not appear in this northern area until around 300 B.C. and beans were cultivated even later, around 400 A D. (1).

The available evidence shows that early man in the upper Great Lakes region utilized his plant environment efficiently even before he began to control it through agriculture. He appears to have used about 400 different plants: 130 for food and the others for their fibrous content or medicinal value. The food supply varied by season. Then as now maple sap in early spring and wild rice in late summer were among the most heavily used foods. These two items apparently were stored for winter use, as were various tubers, nuts and beverage plants. The beverage plants, especially the nondeciduous hemlock and some medicinal plants, may have been important for their vitamin content (1). Early man also hunted various small mammals extensively, especially the deer and rabbit. He fished the numerous lakes and rivers, further supplementing his protein intake. The total food inventory of early man in the upper Great Lakes area suggests no flagrant qualitative inadequacies that would have led to long-term severe malnourishment. However, the limited storage techniques, seasonal variation and the uncertainties caused by lack of control over the environment must have resulted in periods of famine or temporary general inadequacies.

The archeological record reveals nothing concerning the diet of babies and small children. Ethnographic evidence suggests that babies were weaned only when replaced by a new sibling. Meat was probably pre-chewed and offered at a relatively early age; bone marrow, brains, mashed liver, and other such non-muscular parts of the animal may have supplemented breast milk at an early age.

In the southwestern portion of the present United States, agriculture enabled the people to live in settled villages from early times; here and in the Southeast the earliest Europeans encountered the most highly civilized Indians north of Mexico. Indian corn or maize was the primary crop, but beans and squash were also extremely important. The bean was especially important, perhaps even in terms of cultural advancement, because of its protein content (2). Small game continued to supplement the diet, and hunting is still important and characteristic of many southwestern groups.

THE ETHNOHISTORICAL RECORD: EUROPEAN INFLUENCE

Although Vikings may have visited the northeastern part of the United States very early, the Spaniards were the first Europeans to sig-

nificantly affect North American Indian groups. They arrived almost simultaneously in Florida and in the southwestern United States. The earliest explorers such as De Soto, Cabeza de Vaca, Coronado, Onate, Penalosa, and others left good accounts of the food items the Indians used, since they depended upon them for their own survival. Throughout the southwestern and southeastern portions of the United States, corn was the most important staple, inevitably accompanied by beans and squash. Other items, such as the groundnut in the southeast and the mesquite bean and pinon in the southwest, were also frequently very important. Small game, especially rabbit and deer, and birds, fish, and beaver were available, and occasionally larger game like bison and bear formed an extremely important part of the diet.

Introduction of Horses and Guns

Perhaps the earliest, and certainly the most important, European influences were the introduction of horseback riding and the use of the gun. Wissler (3) and Ewers (4) have detailed the rapid northward expansion of these cultural influences from the Southwest, where they were introduced by the Spaniards in the middle of the 16th century. The use of the horse and gun made pursuit of the bison far more efficient than ever before. Many groups formerly living only on the edges of the Plains gave up a way of life based mainly on agriculture for the nomadic existence characteristic of the historical Plains culture. The needs of the horses for pasturage and water became determinants of the yearly migratory patterns and eventually molded other aspects of the social organization. The Indians' dependence upon the horse became so great among some tribes, such as the Comanche, Pawnee, Sioux, Blackfoot, Crow and others, that they can best be considered pastoralists rather than hunters.

The large, wide-ranging concentrations of people in the Plains area were made possible by these cultural borrowings of horses and guns. Not only was their meat supply sufficient for their own use, but many tribes traded surplus meat to the settled agricultural groups for corn, beans and other products, thereby improving the diets of all concerned.

Herd Animals

In the more arid regions of the Southwest that border the Plains on the west, the introduction of sheep and goats was particularly important in establishing the present Navajo culture. Before the arrival of the Europeans, no domesticated mammals existed in the New World north of Peru, except for the ubiquitous dog. Although cattle, sheep, goats, and chickens were utilized to varying degrees by many Indian groups, only the Navajo took up herding as a primary way of life. At the same time, certain crops were also adopted in the Southwest and elsewhere, some of which (melons, peaches, cucumbers, cabbage, turnips, and wheat) as-

sumed permanent importance in the diet. These items supplemented rather than replaced the native domesticated plants. However, wheat flour eventually tended to replace corn in some areas, usually to the detriment of the nutritional status of the people.

Fur Trapping

If the horse and gun created extensive changes in the lives of the people of the Plains and the Southwest, the northern Europeans perhaps had an equal, although quite different, effect in the northern United States and Canadian areas. The British, French, and Dutch explorers soon found that the northern gold consisted of the hides of the beaver, fox, mink, and other northern animals. Leacock (5) has shown the detrimental effect of the fur trade on the size and composition of the cooperative unit known as the "band."

Population Shifts and Containment

Wilson (6) documented the westward encroachment of northeastern tribes such as the Iroquois upon the more westerly prairie groups. This markedly increased the concentration of population in the Great Lakes area. As an example of dietary persistence despite enforced cultural changes, Wilson noted that incoming tribes retained old preferences and did not adopt wild rice as an important staple, even though it had been a major foodstuff for earlier inhabitants of the region. The dietary preferences here did not correspond to the availability of food items in the local environment. This pattern persisted in spite of the great want which accompanied the overpopulation in the area. This phenomenon has been noted repeatedly in modern times, to the chagrin of innovators and public health officials.

Factors Causing Deprivation

The effect upon the Native American cultures of the continual harassment and containment by the Europeans in both the Southwest and the North was very great. The competition for land and game eventually caused the virtual destruction of the aboriginal way of life in all areas. European tools and methods sometimes made the partial survival of the various cultures possible under the deprived conditions, but in all cases, adjustment to the environment changed the cultures considerably. Trading posts introduced new items for purchase, such as tea, coffee, sugar, lard, flour, tobacco, alcohol, and eventually tinned milk and meat. Not only did the consumption of these items change the nutritional adequacy of the diet, but the life patterns of the people. The desire to purchase them often led the Indians to the search for wage labor and to concentration on hunting animals for fur rather than meat. These changes in turn affected the customary hunting rights and territorial claims. Reciprocity of hunting rights was more often restricted when

animals were hunted primarily for fur and only secondarily for food. When the demands for certain furs or the supply of animals diminished, many tribes had virtually no source of income. The inexorable shrinkage of their territories combined with the lack of income sources eventually created true poverty on a permanent year-round basis for many, if not most, North American Indians.

THE ETHNOGRAPHIC RECORD

The historic cultures discussed here were chosen as examples of adaptation to different ecological zones. The data for the first 20 cultures on the list were taken from the Human Relations Area Files and supplemented by ethnographic accounts; information about the three remaining cultures was added to represent the northern areas more fully. The groups are located on the map (Fig. 1). The dates of the accounts range from 1633 to 1969. The data are not equally reliable, therefore nutritional adequacy cannot be assessed with great precision, although we can estimate its general status and document gross changes in levels of intake over time.

The Southwest

The Pueblo Indians: The cultures noted in the southwest region on the map include the Papago, Tewa, Yuma, Navajo, Zuni, and Zia. The Tewa, Zuni, and Zia are considered Pueblo Indians. They have acquired food by three basic methods: farming; hunting and gathering; and purchases from stores. Farming, the traditional and most widely used method, and purchasing of food are clearly the most important means now, but hunting and gathering may still be of considerable significance in providing the necessary minimum amount of animal protein. The Pueblo diet still consists mainly of corn, beans, and squash, but also includes chilies, melons, pumpkins, onions—either the wild lily or the bulb imported from Europe—and peaches, which also are cultivated (7). In addition, some seeds, roots, berries, greens, and flowers are gathered, and a few small animals such as the rabbit, rat, and prairie dog are hunted. All of these groups buy coffee, baking powder, yeast, crackers, flour and potatoes. Tea and condensed milk, as well as jellies, sweet rolls, cakes and soft drinks are also purchased in large quantities. Fish, wild turkey and wild grouse are important at certain seasons, as are nuts, particularly pinon nuts.

The Zuni Indians herd goats and sheep, and milk their goats, though the extent that milk is used in the regular diet is unknown. Babies are breast-fed immediately after birth and are nursed on demand for one to three years, depending on the custom of the particular Pueblo. Cow's milk is used as a supplement or a substitute for breast milk to an increasing extent. Among the Tewa-speakers, solids are not given to the infant until weaning at about one year of age. Furthermore,

the baby is given water and cow's milk for the first four days after birth to prevent him from drinking the colostrum. The Zia Indians, on the other hand, wean their babies at the age of about two years to black coffee and cereal gruel. Hawley and co-workers, who were specifically interested in diet among the Zia, noted that the daily menus included little meat, with an excess of carbohydrate and fat (8). They estimated the total number of calories eaten per person to be about 2,000 per day. Typical meals relied heavily on corn and chili dishes plus wheat bread, tea or coffee, and sugar.

The Papago Indians: The Papago Indians, like the Yuma and Navajo tribes, share some characteristics with the Pueblos while differing significantly in others. The Papagos not only grow many of the agricultural products noted above, but gather a wider variety of plant foods such as mesquite beans and various wild seeds, fruits and cacti. They dry many plants for storage, which allows them a wide variety throughout the year. They al[illegible]hunt small game, including rabbit, deer, rats, and birds, a[illegible]hey keep horses, cattle, sheep and goats, although their econo[illegible]y does not depend primarily on them.

Babies are nursed for as long as three years, sometimes along with a new infant. In addition, at six months of age an infant is fed broth or juices extracted from various plants. He may also be given coffee at this time and shortly after, mashed beans or potatoes and small pieces of tortilla or orange to suck upon.

Several sources indicate that cow's milk is not generally used because it is disliked. At least one source notes that Papago Indians believe cow's milk to be harmful if not diluted. In general, as with the Pueblo groups, the diet is heavy in carbohydrate, and animal protein is scarce and irregularly consumed. Intake of seeds, especially mesquite beans, with cacti and small wild game is significant. The diet reconstructed from the archeological evidence in this region shows it to be similar to the one described for the present. The diet is also similar to those in Mexico and Central America, as are some of the specific beliefs like those concerning milk, which also prevail in the Mayan area.

The Yuma Indians: Although the general diet of the Yuma is very similar to that of the other southwestern groups, they do not eat several items such as fish, pork, and chicken. They also do not eat birds, nor eggs of any kind—the one exception being quail and quail's eggs. Babies are placed at the breast two days after birth and are nursed for up to four years. Presently they are increasingly fed canned milk as a substitute or supplement. Pre-chewed corn, mashed peaches and mashed juniper berries are added to the diet when the child starts to walk.

The Navajo Indians: The Navajo group is now the largest tribe within the boundaries of the United States. They primarily herd sheep but they also farm. Their crops are similar to those already

noted for the Pueblo groups. Corn, beans, peaches, and melons are important to them, as are various kinds of squash and pumpkin. In addition to these largely carbohydrate foods, they also depend heavily on mutton, goat, and various kinds of bread made from wheat flour. Potatoes, plus coffee with sugar, complete their typical diet. Traditionally children were nursed up to three years and the breast milk supplemented with solids from four months of age.

The Eastern Woodlands

The Micmac, Ojibwa, and Iroquois groups, the most northerly tribes described in this region, formerly depended on a combination of small mammals and fish from the lakes and rivers. As in the upper Great Lakes, these cultures also used berries, wild rice, maple sugar, and a variety of roots, bark, fruits, and lichens. Nuts and acorns were also important and animals as diverse as caribou, deer, moose, bear, muskrat, and beaver were hunted, as were wild fowl of various kinds. Civilization has somewhat decreased dependence on these foods and increased the consumption of purchased items such as salt pork, canned milk, flour, tea, coffee, and refined sugar. Potatoes are now an important item in the diet, but other vegetables are practically unknown. The Iroquois, in addition to the diet noted above, also cultivated corn, beans and squash, as did their more southerly neighbors, the Creek and Delaware.

In all of the Eastern Woodlands groups, babies are still nursed to the age of a year or so, though it used to be common for three- and four-year-olds to be breast-fed. Mothers may nurse two children at once. The first foods were pre-masticated meat and vegetables, such as potato, pumpkin, and beans, the liquid from the boiled corn, containing wood-ash, soft-boiled wild rice, and even flaked fish.

Southward in the Eastern Woodlands area, different types of plants and animals were gathered and hunted. The more important large mammals were bison, bear and deer, and eventually as these disappeared, smaller mammals, such as rabbit, became more important. However, these groups depended largely on agriculture even before the conquest, and they quickly adopted many of the crops introduced by Europeans such as cucumbers, melons, cabbage and turnips.

Among the Micmac, infants were breast-fed immediately after birth, since the colostrum was thought beneficial to the child's health. However in many groups today breast-feeding has declined both in popularity and duration, and canned milk is being substituted almost universally.

Early patterns of diet in the entire Eastern Woodlands area persist despite the changes brought by civilization and reservation life. In the North, hunting continues to satisfy the appetite for meat. Indians south of this area still eat the early diet of corn, beans, and squash, but supplement it with a variety of other vegetables and fruit. Within this original pattern, new items have been adopted, usually to the detriment of the nutritional adequacy of the diet.

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The California Groups

The California groups--the Yokuts, the Pomo, and the Yurok--formerly depended on acorns and a wide variety of sea foods. Oysters, various kinds of mussels, sea urchins, barnacles, rock fish, and even sea mammals such as whales and sea lions, were important. Land mammals, including elk, deer and squirrels were also hunted, along with various kinds of fowl. Flour made from the acorn provided the main staple and enabled these people to live a relatively stable existence in the valleys and along the coast of what is now California.

Yokut babies were nursed for varying periods. An early source states that some were nursed for several years. However, among the Yurok group now, babies are breast fed only six to seven months in most cases, with one year considered the longest appropriate time. Young children are given gruels made of acorn flour and broth from meat or fowl. In some cases, pre-masticated meat is also given as a dietary supplement to relatively young children.

The Plains Tribes

The tribes of the Plains include the Crow, Pawnee, Gros Ventres and Mandan. Of these, the Pawnee and Mandan not only depended upon large game, especially buffalo, but crops that included the familiar trio of corn, beans, and squash. Although the Plains tribes notoriously depended on the buffalo, they used other game found in the area, including elk, deer, antelope and various kinds of birds as well as fish. Bird eggs were gathered whenever possible, and dogs--especially young puppies--were a favorite meat. Various berries and roots were gathered as supplementary foods and often preserved by drying, thus allowing some variety year round.

The dietary pattern of the Pawnee and other southern Plains tribes comes closer to that already noted for the southwestern groups than for the northern Plains. Corn, beans, squash and pumpkin, as well as wheat and oats in modern times, form the basis of the diet, with fish and wild animals, such as elk, deer, bear, beaver, otter, raccoon, badger and fish as supplements.

Among these tribes it is reported that babies were nursed from two to six years. Supplements to the breast were given early and most often consisted of meat broth, pre-chewed meat, marrow, and other soft animal parts. A ball made of cooked roseberries and grease from the game was often given as the first solid--almost like a lollipop according to one writer--that could be sucked and chewed by the child when he wished.

All of these tribes have attempted to maintain their native pattern whenever possible, but increasingly have depended on items purchased at stores and trading posts. The demand for sugar, coffee, tea, flour, and lard is noted for all of these groups in modern times.

The Northwest Coast Groups

Fish is the staple for several groups in the Northwest Coast area, represented here by the Nootka and the Bella Coola. Although salmon is the most important species of fish caught in this area, others are halibut, herring, anchovies, and various kinds of shellfish. They also hunt sea mammals such as seal and whale. Land mammals, including bear, deer and wild goat, and ducks and geese may be eaten, but at least among the Nootka, the latter are not particularly relished. Agriculture has never been important to this culture, and recent attempts to encourage gardening have largely failed. In ancient as well as modern times, some berries, roots, and wild birds' eggs were collected but now provide only a small part of the total diet. Some important items available at stores or trading posts include beans, sugar, molasses, honey, flour, potatoes, rice, canned milk and meat, and tea. Cook in the late 18th century noted that the Nootka depended almost entirely on the sea for food. The latest ethnographic evidence (9) indicates that in the early 1940's 80% of the food supply was imported. Fish, however, still formed an important and well-liked portion of the diet.

Babies were breast-fed by the mother or a near relative if the mother died in childbirth or was unable to nurse. Feeding on demand continued as long as two to three years. Among the Bella Coola, soft powdered salmon mixed with water was given fairly early.

The Arctic and Subarctic

An extremely high caloric intake, consisting largely of protein and fat, is characteristic of the Arctic and Subarctic cultures. The body probably requires more calories simply to maintain warmth in the severe winter months. The high protein diet is associated with a higher metabolic rate, which also raises the amount of calories needed (10).

The Attawapiskit and the Dogrib: The Subarctic groups, including the Dogrib and the Attawapiskit still eat a diet largely unchanged from the aboriginal and the early contact periods. Thus, these hunters still prefer wild game and so-called "country food" to the products of modern civilization with the exception of flour, lard, tea, coffee, sugar, oatmeal, and other such purchased items. Gardening to encourage the consumption of fresh vegetables has been notoriously unsuccessful here in an area where the growing season is short. Furthermore, the common situation of feast or famine still appears to be a feature in these cultures. Honigmann (11) listed sample winter diets for the Attawapiskit and included only the following: unleavened wheat bread, lard, tea, canned milk, sugar, beans, corn syrup, oatmeal, jam, raisins, and potatoes, all of which were purchased. Occasional meals included rabbit, white fish, beaver, and ptarmigan. Honigmann also noted the collection of berries, rhubarb, birds' eggs, buds, sap, reeds,

roots, moss, and spruce gum depending on the seasons. However, none of these formed a substantial portion of the diet. The unpublished work of Helm indicates substantially the same patterns among the Dogrib (12). These people recognize and collect various foods growing wild in their area, but depend almost entirely on game and purchased foods.

Honigmann, in his description of the diests of 17 Attawapiskit children, noted that the length of breast-feeding varied from 12 to 25 months. Eight were nursed for at least 24 months. No information on Dogrib breast-feeding is available.

The Alaskan Eskimo: Like the inland tribes of the Subarctic, the Alaskan Eskimo eats mainly game and "store-bought" items. Depending upon his location, the Eskimo hunts sea or land mammals or combines the two as the seasons progress. During the summer he concentrates more upon fish and some sea mammals, especially the whale. One fact not well known outside the Arctic and Subarctic is that the middle of summer is a period of low food supply. Fish and game are scarce and plant foods available in the spring and fall do not yield much between these seasons. In the most severe winter months of December and January, hunting may be precluded by the vagaries of the weather. The normal freezing temperatures during the winter months permit storage of excess game to insure a more even daily intake. With the spring thaws this storage method disappears along with the game itself.

As with other hunters, especially in the Plains, the introduction of guns in the early stages of European contact changed the Eskimo way of life considerably. With guns, larger numbers of game could be killed. This sometimes had the effect of lowering the total amount of game available since, according to numerous travelers' accounts, some Eskimos tended to kill more than was actually needed at any given time. The consequent early depletion of certain animals, particularly caribou and reindeer, caused extreme hardship for those largely dependent upon them. Even though the balance of nature has been somewhat restored and most hunters now recognize the value of conservation, the earlier periods of scarcity changed the consumption patterns in the direction of foreign, "store-bought" foods. The supply of sea mammals was not so affected, thereby giving an advantage to the coastal Eskimo over the inland groups. The fur trade has affected the Eskimos considerably, since many groups concentrated on hunting furs, such as the white fox, at the expense of food-acquiring activities. The money obtained from the sale of furs was increasingly used for the purchase of prepared foods of questionable nutritive value, as well as for tobacco and alcohol.

DIETARY TABOOS

Food taboos, especially those during the pre- and post-natal periods,

are worth noting particularly because of their effects on the nutritional adequacy of the diets of pregnant and lactating women. Among the Southwestern Indians, the Tewa prohibited women from drinking milk for four weeks after childbirth. They also considered several species of animals and birds unfit for all to eat, including wolf, coyote, eagle, hawk, and the turkey vulture. Among the Papago, salt and sweets were restricted in the new mother's diet until the newborn baby's umbilical cord fell off. For the first few days after birth, the mother ate only a gruel made of maize or wheat flour flavored with the seeds of the sahuaro cactus. Among the Yuma, the women did not eat salt for one month before giving birth nor meat for one month before and after the birth.

Among the proscribed foods among the Navajos were fish, bacon, and chicken, which are still disliked by most traditionally oriented tribe members. Since eggs were thought to increase the fertility of women, they were often avoided unless a child was desired. A woman's milk supply was believed to increase if she drank broth made from blue corn meal for several days after childbirth. It was also believed that Navajo women should restrict their intake of meat, potatoes, beans, and bread containing salt or baking powder for a short time after childbirth.

In the Eastern Woodlands, the Delaware Indians discouraged pregnant women from eating cabbage, onions, salt, and very sour foods, as well as liver, rabbit and groundhogs. During a fever, meat of all kinds was prohibited. The Ojibwa encouraged pregnant women to eat venison, wild rice, lake trout and white fish in the belief they would produce healthier babies and increase the mother's milk supply.

Among the Yokuts in California, women limited their meat and salt intake for three months after giving birth. The Pomo also observed food taboos during the postnatal period, forbidding the mother to eat snakes and frogs. Another kind of taboo forbade the intake of the totem animal of the particular kinship group. This kind of taboo had the dual effect of increasing the feeling of solidarity among the group members and facilitating a better distribution of the available animals among the population through a kind of symbolic rationing.

The Crow Indians of the Plains placed a taboo on all fish and stream "creatures." Mice, rats, snakes and moles were also forbidden, as were turtles and owls. All of the Plains tribes placed a taboo on horse meat. In the Northwest Coast area, most of the taboos relating to diet involved some item of seafood. Among the Nootka, a woman could not eat cod, squid, halibut, spring salmon, seal, sea lion, or whale for one year after childbirth. She was also denied huckleberries and salmon berries. A general taboo on bear and deer has also been noted. Among the Bella Coola, salmon was denied a girl for one year after puberty, and the same taboo served as a symbol of mourning for deceased relatives. Females were not permitted seal or bear, and if they were of childbearing age, beaver was prohibited. On the other hand, except for the foods noted, few restrictions occurred during pregnancy itself.

More recent sources do not indicate to what extent, if any, these taboos and dietary customs currently prevail.

DISCUSSION

According to the food inventory of each of the different ecological zones, the essential nutrients appear to have been readily available to the North American Indian. However, the intense seasonal variations could well have produced a "feast or famine" situation accompanied by periods of malnutrition due to insufficient calories and specific nutrient deficiencies. Even among the agricultural groups which could store grains for the winter, a similar pattern of intermittent deficiencies probably also occurred. Many early travelers and modern ethnographers noted that the American Indians were frequently capable of fasting for several days when necessary, countering this by heavy feasting when larger amounts of food were available. A number of other customs seem related to this pattern of food intake. The puberty ceremonies among many North American Indian groups, especially for the males, involve a period of fasting that might last several days. Similarly, a young girl might be required to fast during her menstrual periods. Reinforcement of fasting through these rituals certainly must have aided them during times of actual scarcity.

On the other hand, many accounts describe wholesale gorging and stuffing with food during times of plenty. Many early accounts suggest that men were capable of eating from 10 to 20 pounds of meat in one day (12). Although this amount sounds improbable, evidence from various sources suggests that they did indeed occasionally consume such quantities. The consequences of this "feast or famine" phenomenon are unknown. Modern medicine usually stresses the physiological advantages of regularly spaced meals and regular intakes of specific nutrients.

The food taboos noted seem mainly to have originated in the Native rather than the European culture. Many of these have disappeared along with changes in the general availability of food and modification of consumption patterns. Nevertheless, some of the taboos are particularly interesting. For instance, in several of the groups mentioned pregnant women refrained from eating salt. Since some pregnant women tend to retain fluids, these restrictions seem quite modern.

The wide variety of customs concerning the appropriate time to put the newborn to the breast probably reflects European influence, which discouraged the intake of colostrum. The total period of breast-feeding probably has declined, but reports show that breast-feeding is still practiced. In some groups, breast-feeding continues for a sufficient period of time to protect the infant during the early period of rapid growth. Important also was the relatively widespread custom of supplementing breast milk with foods from the adult diet, usually processed to make them more acceptable to infants. Many of these foods contained protein and would have increased the infant's chances of survival in a harsh world.

The observation that the Delaware Indians eliminated meat from the diet when a patient had a fever sounds very much like the reasoning of Hippocrates introduced into the New World by Europeans. The restriction by the Plains Indians against eating horse meat, on the other hand, seems based on the importance of the horse in their way of life. The horse was not only important for obtaining food, but was imbued with symbolic value unequalled by other domesticated animals. The restriction is like the totemic taboos noted for the Californian and Northwest Coastal tribes in which an animal was considered to be so closely linked with a particular group that to eat it was considered almost a form of cannibalism.

CONCLUSIONS

Despite the fact that we know relatively little about present diets among American Indians, we can probably make a few generalizations. First, dietary customs have persisted longer than might have been expected. Not only are aboriginal foods traditionally prepared, but preferred, and some of the social mechanisms still exist for distribution of food within the domestic circle, if not on a broader scale. Certain foods have retained their religious and ceremonial significance, and no foods adopted since European immigration have been raised to ceremonial status. Even though the normal diet may consist almost entirely of foods purchased nearby, on feast days aboriginal foods are given stellar places.

Second, the diet has deteriorated in terms of some nutrients. Although not all of the geographic areas provided adequate amounts of protein, probably only in modern times has severe protein malnutrition occurred. While periods of protein scarcity occurred, sufficient supplements to the plant foods appear to have been available to have kept most of the population in fair health. Not everyone survived periods of scarcity, but probably the sick and weak died first. As hunting areas decreased with the encroachment of "civilization," the problem of obtaining animal protein became acute. In those areas where game could be found only occasionally and formed only a minor part of the diet anyway, its disappearance could likely create nutritional deficiencies such as kwashiorkor. On the other hand, in those areas where hunting was the primary basis of the economy, inability to find sufficient game could have led to starvation had it not been for the stores and trading posts.

In all areas, the kinds of foods now purchased for most meals tend to be relatively standard: flour or wheat bread, sugar, lard (especially in the Arctic or Subarctic), tea, coffee, oatmeal, syrup, molasses or honey, and to a lesser extent, canned milk and meat. The increasing dependence upon purchased supplies results in the popularity of soft drinks and sweets, such as sweet rolls, cakes, doughnuts, and others that are available in every store catering to Indians. Other processed so-called luxury foods such as crackers and potato chips are also popular. Many of these contribute little to the diet except calories.

The amount of money available to each family primarily determines the food which may be purchased and therefore markedly influences the adequacy of the diet. However, contrary to expectation, it is possible that families with less money in fact may have fewer problems of malnutrition. Such families may be more likely to gather wild plants rich in vitamins and other foods containing protein, such as eggs, insects, and small game. The family with slightly more money from wage labor, craft sales, or fur trading may spend it on luxury foods with less nutritional content. In such cases, the poorer family, though possibly better off nutritionally, probably does not perceive this advantage and probably would classify itself as more poorly fed than its richer neighbors. Such families are not actually well off, since their lack of cash denies them other goods and services now considered necessities, and their social prestige probably suffers. This paradox is not new to nutritionists and public health workers, who have encountered it throughout the world.

In addition to buying low-nutrient foods, the customs of food distribution seem to have changed considerably through acculturation. Once widely distributed throughout the kinship units and sometimes throughout the tribe, food was an item denied to no one in need. Both formal and informal mechanisms existed for distributing it as widely as possible. Several writers have noted changes in social organization and world view as concomitants of civilization. Break-downs have occurred particularly in the kinds of cooperation noted by almost all early observers. Not only did kinship rights and obligations require that hunters share their catch with their relatives, but there was the custom of granting hunting privileges to anyone needing them. The private or family-owned hunting territory seems to have developed in response to the pressures of the fur trade (5). Even today in the Subarctic, where hunting is still the basic means of obtaining food, private hunting territories that exclude alien hunters are unknown, but only when competition for furs is not a factor.

The older food distribution patterns had positive survival value during periods of scarcity. Conversely, the new emphasis on individual acquisition may reflect a more stable, certain food supply. The establishment of the trading posts with their canned and packaged foods probably has allowed somewhat greater stability, even though the general adequacy of the diet has undoubtedly deterioriated.

Feasts of various sorts are still held, usually on ceremonial occasions such as life crises, seasonal changes, and modern holidays. Food is an important element in these, even to the extent of providing unlimited amounts to all strangers who appear. In the literature on almost all groups studied, it is repeatedly noted that a visitor must be served some small item of food or given something to take away. These customs still effectively set boundaries between Indian and non-Indian culture in North America, for the non-Indian simply does not understand this way of life. While non-Indian Americans also customarily offer food or drink to vistors, they are not likely to offer them a pound of potatoes or a beef

steak to take home. As such, the non-Indian customs serve not so much to redistribute the food supply, as to express symbolically one's friendship and/or social status, while the Indian customs do both.

Overall, lack of funds and an environment more circumscribed through time seem to be the primary limiting factors in better nutrition for the American Indian and Alaska Native. They obviously need higher incomes to enable them to eat better. From a practical point of view, the American Indian should be encouraged whenever possible to retain or revert to some of the older dietary patterns. Many of the aboriginal beliefs and practices seem to have been beneficial or at least not harmful to health, and the foods themselves, when consumed in adequate quantities, were probably adequate nutritionally. The major dietary disadvantage appears to have been lack of stability and consistency of food supply through the seasons, possibly leading to famine or nutritional deficiency diseases for weaker individuals at certain times, though specific quantitative evidence for this is so far lacking. Obviously some of the earlier foods such as bison are no longer generally available, but Indians on reservations frequently are still allowed to hunt. If hunting were encouraged and frozen food lockers made generally available, protein intake might increase. More prestige could be given to the plant foods available, and education could be effective in pointing up the hazards of eating too many sweets and carbohydrates to the exclusion of other nutrients.

Production of some of the traditional foods by Indians on a commercial basis might be feasible. In the Southwest, such items as blue corn tortillas, whose nutritional quality is higher than the unenriched white bread now eaten by most Indians, are already marketed. However, such enterprises usually are controlled by non-Indians. In Minnesota, Chippewa Indians gather and sell wild rice--although mostly to non-Indians. Pueblo Indians formerly sold homemade bread in the plaza of "Old Town" in Albuquerque, but were recently prohibited because the bread was not baked under controllable sanitary conditions. Schemes to help Indians conform to existing sanitary codes or alternately to change unreasonable or unnecessary laws would help maintain the prestige of native foods and supplement the income of the people. The recent reawakening of ethnic identities among Indian groups as well as other minority groups could be utilized as a framework to encourage the readoption of traditional foods.

COMMENT

Many of the Tribal Representatives sharply disagree with the observation that the introduction of guns led to even the temporary and limited overkilling of animals described, reporting no such overkilling in their areas. Gonzalez agreed that most of the reports came from an earlier period and might not apply now; nevertheless, when food was needed, the whole animal was used, while during periods of plenty, only choice parts were eaten. Anthropologist Margaret Lantis emphasized

the enormous size of Alaska, with its great variety of peoples, hunting conditions, weather and life situations. One condition where all of the meat might not be used is the harvesting of animals for ivory by those who earn their living from ivory carving. Recent observations in northern Alaska by Nelson (13) show that the Wainwright Eskimos strongly oppose waste in walrus hunting, taking all practical measures to minimize it. Occasionally when they find rotting carcasses from the south resulting from ivory harvesting, they speak extremely disparagingly of the practice. However, the fact that such carcasses do appear substantiates the claim that some groups kill primarily for ivory to carve. In other cases, hunters caught in poor weather without time to butcher the animal have had to abandon their kill. Non-Indian sportsmen using planes to hunt polar bears have slaughtered large numbers of animals. As Nelson's observations illustrate, attitudes towards the practice of such killing vary greatly within the Alaskan groups, depending on whether ivory is vital to survival in a wage economy.

NOTE: Dr. Nancie Gonzalez was with the Department of Anthropology, University of New Mexico, Albuquerque, New Mexico at the time of the Conference. She is currently with the Department of Anthropology, University of Iowa, Iowa City, Iowa.

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PHYSICAL GROWTH OF NORTH AMERICAN INDIAN AND ALASKA NATIVE CHILDREN

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Physicians, nutritionists and school personnel seeking to meet the health and educational needs of North American Indian and Alaska Native children are often called upon to collect and/or interpret physical growth data. In doing so, they may encounter problems relating to sampling procedures, measurement techniques, and methods of data reporting. As a result, manpower and other scarce resources may be invested in obtaining height and weight information of limited reliability and practical value.

Many clinics, schools and special programs record physical growth data on a routine or sporadic basis, but these data are usually difficult to retrieve and may not provide an accurate reflection of the growth status of individuals or groups, much less their developmental patterns. Greater attention to sound principles of sampling, measurement and reporting could enhance the value of these data. Additional carefully designed cross-sectional and longitudinal studies could do much to augment existing fragmentary knowledge of the physical growth of American Indian and Alaska Native children.

PHYSICAL GROWTH STUDIES

An extensive review of the literature, both published and unpublished, reveals many reports which contain anthropometric data for different Indian and Native groups. Height and weight data are often

presented in conjunction with other types of data, including craniofacial measurements (1-8), post-cranial skeletal dimensions (1,4,6,7,9), skinfold thickness (6,10,11) and a variety of biochemical findings (10-13). Data presented in some reports are of somewhat limited value in the present review because they refer to only a small number of subjects in each age-sex group (6,14), a limited age range (15,16), or only one sex (9,17). Some reports display anthropometric data in figures rather than tables (3,13), or omit primary growth data and specify only percentiles (16,18,19) or growth channels (20).

TABLE 1

Mean Height (Inches) of Indian and Eskimo Boys and Girls Compared with a U.S. National Sample

Boys	Age (years)					
	6	7	8	9	10	11
National Sample (24)	46.7	49.0	51.2	53.3	55.2	57.4
Apache (3)	42.1	45.1	48.5	50.4	52.4	55.1
Assiniboin/Gros Ventres (12)	46.6	49.3	51.3	53.4	55.7	57.6
Blackfeet (11)	46.7	48.7	51.1	53.7	55.3	57.9
Navajo (13)	44.6	47.0	49.5	51.2	52.8	53.1
Alaskan Eskimo (22)	44.4	46.3	48.6	50.1	52.1	54.4
Girls	**Age (years)**					
	6	7	8	9	10	11
National Sample (24)	46.4	48.6	50.9	53.3	55.5	58.1
Apache (3)	43.7	46.2	47.3	50.5	51.3	53.6
Assiniboin/Gros Ventres (12)	45.4	48.9	50.6	53.8	55.6	57.2
Blackfeet (11)	46.7	48.4	51.3	53.2	55.4	58.4
Navajo (13)	44.3	45.4	48.9	50.5	52.9	54.9
Alaskan Eskimo (22)	43.2	45.1	47.9	49.4	52.0	53.5

Physical anthropologists tend to focus their attention primarily although not exclusively on adults (1,2,4,5,7,8), whereas physicians and nutritionists tend to give equal or occasionally greater emphasis to growing children (12,21). Many anthropometric data are contained in reports of nutrition surveys (10-12) while additional physical growth information may be found in experimental nutrition studies (17) and case reports of nutritional disease (22).

Height and weight data are relatively more abundant for the school age child than for infants and preschool children. It is thus difficult to compare children from different tribes prior to school age and virtually impossible to make comparisons within tribes over time. In contrast, tribal and secular comparisons are possible for Indian and Native children in the elementary school age range. Pertinent studies are outlined in the following paragraphs and the data are shown in Tables 1 and 2.

TABLE 2

Mean Weight (Pounds) of Indian and Eskimo Boys and Girls Compared with a U.S. National Sample

Boys	Age (years)					
	6	7	8	9	10	11
National Sample (24)	48	54	61	69	74	84
Apache (3)	41	42	49	58	63	66
Assiniboin/Gros Ventres (12)	48	56	63	73	81	87
Blackfeet (11)	49	54	61	68	75	85
Navajo (13)	45	49	54	55	62	67
Alaskan Eskimo (22)	48	52	58	65	70	75

Girls	Age (years)					
	6	7	8	9	10	11
National Sample (24)	47	53	61	69	77	88
Apache (3)	46	50	53	62	66	75
Assiniboin/Gros Ventres (12)	45	53	58	67	82	80
Blackfeet (11)	48	52	59	66	73	83
Navajo (13)	43	45	55	58	66	77
Alaskan Eskimo (22)	42	48	55	59	67	75

HEIGHT AND WEIGHT OF INDIAN AND ESKIMO CHILDREN

In the Summer of 1954 Kraus recorded a number of physical dimensions on Indians of the Fort Apache Reservation in east central Arizona (2). An anthropometer was used to measure height and clinic scales were used to record weight. Only the subjects' shoes were removed. Age-sex groups varied in number from 5 to 23 children.

Kraus emphasized the lack of uniformity of types of data, statistical treatment, and sampling procedures in the various studies on the physical growth of Southwestern Indian populations. Further, he noted the long time span involved in undertaking these investigations and questioned the value of comparative tables. He felt significant anthropometric differences could be demonstrated in populations if their biological divergence is obvious on historical, linguistic, ethnological and gross morphological grounds, but questioned whether the anthropometric approach is sensitive enough to detect genetic divergence within the same racial stock.

Following the above philosophy, Kraus thus compared Apache, African Negro and American white adult males on five body measurements and found substantial differences. Comparing a number of Southwestern Indian groups, however, he found only marginal differences. In comparing the height of Apache children with white and Negro girls, he found no major differences in the 6- to 11-year age inter-

val. Nor was there any differentiation in mean weight for age among Apache, white and Negro girls, but Apache boys weighed less than the three groups of girls with whom they were compared. There appeared to be no differences among the three stocks in growth rates as indicated by the slopes of regression lines.

The Interdepartmental Committee on Nutrition for National Defense (ICNND) conducted a nutrition survey of the Fort Belknap Reservation in August-October 1961 (11). The reservation, located in north central Montana, contained approximately equal numbers of Gros Ventres and Assiniboin Indians. Every child attending school on the reservation and many children attending school off the reservation were included in the survey. Age-sex group sample sizes varied from 14 to 28 for 6- to 11-year-old children. The average height and weight values were plotted on the Iowa Growth Charts which are used extensively in the U.S. and derived from both cross sectional and longitudinal studies of middle and lower-middle socioeconomic class children of North European ancestry. In the 6- to 11-year age range, heights and weights were almost entirely at or above the Iowa means for both sexes. Boys on the Fort Belknap Reservation tended to weigh more than the reference children, particularly between 9 and 11 years of age.

At about the same time as the Fort Belknap study, the ICNND performed a nutrition survey of the Blackfeet Reservation (10). Located to the west of Fort Belknap, the reservation had over 1,200 children enrolled in its schools. The entire student bodies from some of the schools and odd or even numbered grades from other schools, with the exception of one, were sampled. Age-sex group sample sizes varied from 31 to 63 in the 6- to 11-year age range. As with the Fort Belknap study, average heights and weights were recorded on the Iowa Growth Charts. Children 6 to 11 years old again demonstrated a close approximation of the Iowa values with a less striking increase over the reference children in boys' weight.

Darby and colleagues had previously conducted a nutrition survey during the summer of 1955 in the areas around Ganado and Pinon, Arizona (12). While Ganado reflected considerable influence of the white man's culture and was readily accessible to urban centers and Pinon had been less penetrated by the white man's culture and was relatively isolated, anthropometric findings did not differ in relation to locale. Data from the two areas were therefore combined to yield age-sex groups of 5 to 36 between the ages of 6- to 11-years. Measurements were made with the children stripped to the waist and without shoes.

Choosing to compare average heights and weights of the Navajo children with data from a recent Canadian sample, Darby's group found no significant height differences for either sex in the younger groups within the 6- to 11-year age range, but for the older groups in this range the Canadian children were taller. With respect to weight, the Canadian children were consistently heavier than the Navajos between ages 6 and

11 years with the differences increasing appreciably in the older age groups, especially for the boys. In another comparison, Darby and co-workers used the older Baldwin-Wood standards for U.S. children and expressed the Navajo weight data as the "percent of standard weight." For both sexes, increasing age was associated with an increasing percentage of Navajo children less than 80-90% of standard weight.

In 1967, Heller and co-workers published height and weight data for northern and southern Eskimos obtained on all children in nine villages (21). Weight was measured on a spring scale and adjusted to nude weight by subtracting the weight of indoor clothing. Age-sex groups varied in size from 14 to 29 in the age range of 6 to 11 years. The mean heights and weights of the Eskimo boys and girls were compared with composite growth standards for U.S. white children and found to be well below the means for the reference children. Height of the Eskimos in the 6- to 11-year age range in particular was close to the fifth percentile of the standards, whereas weight was closer to the means of the standards. Taken together, these findings indicated a heavier weight per unit of stature for Eskimo children when compared with white children of similar age in the U.S.

Comparisons with a U.S. National Sample

Recent data from Cycle II of The National Health Examination Survey (23) provide a meaningful standard for demonstrating differences in mean height and weight between the various tribes and a National Sample of U.S. boys and girls 6 to 11 years of age. These data obtained with the children in stocking feet and examination clothing which was not deducted from the reported weights are also shown in Tables 1 and 2. Mean height demonstrated an approximately linear increase for both boys and girls in the 6- through 11-year age range whereas the increase for weight was not quite so regular. There was no definite trend in racial comparisons of height and weight except that Negro children tended to be taller than white children and white children tended to be heavier. Both boys and girls in the Northeast and Midwest tended to be taller and heavier than in either the South or West.

The significance of the National Health Examination Survey data derives from the fact that they are based on a statistically representative sample of noninstitutionalized children in the continental U.S. whereas most other anthropometric studies in this country have utilized samples limited according to ethnic, geographic or socioeconomic factors. It is noteworthy that the height and weight averages from the National Health Examination Survey exceeded those of virtually all previous studies with which they were compared. This finding may be attributable to the phenomenon of secular change, i.e., the widespread tendency for body size of a particular population to increase through time, which is discussed subsequently with particular reference to Indian and Native groups.

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With few exceptions the Apaches and to a lesser extent the Alaska Eskimos manifest lower mean heights and weights than the National Sample and the other tribes. No tribe consistently exceeds the mean height and weight of the National Sample, but the Assiniboin, Gros Ventres and the Blackfeet closely approximate the values of the National Sample.

The interpretation of these findings, however, is not easy. The measurements were made at different times by different investigators. There are genetic differences and differences of environmental conditions among the various groups. Accordingly, generalizations should be made cautiously, if at all. Indeed, it is best to view such data as simply benchmarks for the description of individual children or groups of children from these or other tribes. They may be taller or shorter, heavier or lighter than the mean values listed. This is not the same as saying they are accelerated or retarded in their growth. Such designations should be reserved for situations where growth at successive ages is clearly deviant from appropriate reference standards and associated with known or suspected causal factors.

SECULAR CHANGE

To date, there appears to have been only one published report focusing exclusively on secular change in the physical growth of North American Indians or Alaska Natives (7). Miller in 1967 measured 143 sons of 355 Western Apache men who had been measured by Gabel in 1940. He found somewhat surprisingly that the onset of maturity was reached earlier in 1940 than in 1967 thus requiring extensive mathematical corrections to deal with the data. However, univariate analysis comparing each son to his father demonstrated increases of 1.3 cm in stature and 12.9 pounds in weight in one generation.

Miller observed that there have been many changes on Apache Reservations during the last few decades in diet, medical facilities and care, general living conditions, and associated cultural values. He hypothesized and, in fact, found associated biological changes but was careful to point out potential sources of bias such as sibling variability and the weighting of fathers according to the number of sons as well as the problems inherent in correcting for immaturity. The small increase in stature was comparable to that of U.S. Army recruits over approximately the same interval. The rather substantial increase in weight was slightly less than that of men in the general U.S. civilian population measured in 1960-62 as compared with World War II army inductees.

In concluding that the major secular trend in Apache men has been toward increased weight and not toward increased height, Miller pointed out that dietary patterns have shifted toward more starch and carbohydrate rather than more animal protein. This together with an increased caloric intake provides a plausible explanation for the observed increase in weight without a correspondingly large increase in height.

Large secular increases in height may be linked to per capita consumption of animal protein and the quality rather than simply the quantity of the diet.

The present review of Indian and Native physical growth suggests the possibility that the small secular increase in stature found by Miller between Apache fathers and sons may not hold up when non-relatives within the same tribe are compared or when comparisons of non-relatives within different tribes are made. Thus, Hrdlicka reported in 1935 an Apache male adult mean stature of 169.1 cm (1) and Kraus in 1961 listed 168.0 cm (2), a decrease of 1.1 cm. With respect to other Indian groups, Hrdlicka indicated a Papago male adult mean stature of 170.9 cm (1) and Kraus, quoting Gabel, reported 168.8 cm (2), a decrease of 2.1 cm. Within the same Indian Tribe, Hrdlicka reported a Navajo male adult mean stature of 169.9 cm (1) and Kraus, again quoting Gabel, listed 169.6 cm (2), a decrease of 0.3 cm. For Navajo adult females, Hrdlicka listed a mean stature of 157.4 cm (1) while Steggerda reported 155.7 cm (9), a decrease of 1.7 cm.

Whether the above decreases in adult stature within different Indian groups are due to differences in sampling, measurement techniques or other methodologic discrepancies cannot be determined with certainty. Indeed, the differences are not large and might conceivably represent random variation if the measurements were made concurrently on different segments of the same population. However, they were made over variably long intervals of time and thus may be representative of a secular decrease in adult stature. Viewed most optimistically, these comparisons could represent a relatively stable adult mean stature. In any case, they certainly do not indicate the secular trend of increasing height seen in other segments of the U.S. population.

Data for the most part are lacking to make similar comparisons for secular trends of adult weight. On the other hand, both height and weight data are available for 6- to 11-year-old Navajo children. These

TABLE 3

Mean Height (Inches) of Different Groups of Navajo Boys and Girls Measured at Successive Times over 32 Years

BOYS (Time)	Age (years)					
	6	7	8	9	10	11
1936 (25)	46	48	50	52	53	55
1956 (13)	45	47	50	51	53	53
1968 (26)	45	47	49	51	53	54
GIRLS (Time)						
1936 (25)	45	47	49	51	53	55
1956 (13)	44	45	49	51	53	55
1968 (26)	44	47	49	51	52	54

are displayed in Tables 3 and 4. The earliest data were published in 1936 by Steggerda and Densen (24) and were obtained from government boarding schools and day schools on the Navajo Reservation in Arizona and New Mexico. Children known to have any white blood were excluded from the study. Clothes were reduced to a minimum and shoes were prohibited. The average weight of clothing was subtracted from the measured weight before recording. No sex-age group had fewer than 65 children and many groups had 130 or more. The height and weight data for the intermediate group of Navajo children were drawn from the study of Darby and co-workers (12), the details of which have already been described. The most recent anthropometric data were obtained by Hawk in the spring of 1968 from classroom growth charts at the Toyei, Kinlichee and Greasewood boarding schools on the Navajo Reservation (25). Many people made the measurements on many different instruments. Weights were recorded with the children fully clothed except for shoes. Thus, recorded weights were greater than actual weights by an unknown and probably variable amount. Most age-sex groups in the 6- to 11-year age range contained at least 30 students. Many groups included 60 or more students while only a few contained less than 25 children.

It is obvious from the data in Table 3 that there has been no real change in the height of the Navajo children studied over the past 32 years. In contrast, depending on age, weight as shown in Table 4 appears to have increased from two to six pounds for Navajo boys and from three to five pounds for Navajo girls. It is important to remember, however, that the 1936 (24) and the 1968 (25) studies differed in one significant feature. The former recorded weight corrected for the average weight of clothing whereas the latter recorded weight fully clothed without subtracting the weight of clothing. This methodologic difference could therefore account for a substantial proportion, but probably not all, of the secular increase in weight of Navajo children.

TABLE 4

Mean Weight (Pounds) of Different Groups of Navajo Boys and Girls Measured at Successive Times over 32 Years

BOYS (Time)	Age (years)					
	6	7	8	9	10	11
1936 (25)	44	48	53	58	63	67
1956 (13)	45	49	54	55	62	67
1968 (26)	46	51	57	63	69	72
GIRLS (Time)						
1936 (25)	42	47	51	56	62	69
1956 (13)	43	45	55	58	66	77
1968 (26)	45	51	54	61	66	69

The finding of little or no secular increase in height in Western Apache men, adult members of other tribes and Navajo children is not unprecedented although it is rather rare. For example, Hunt and coworkers observed that the Micronesians of Yap were no taller in 1948 than their ancestors in 1876 (26). More pertinent to this presentation, however, is the fact that Partington and Roberts found no evidence of a secular increase in the height of Eskimo school children from the east coast of Hudson Bay over the past 30 years (27). A subsequent report by Schaefer, on the contrary, contends that different groups of Canadian Eskimos conform to the general secular growth acceleration patterns observed in almost all populations coming under the influence of modern civilization (28).

The finding of a secular increase in weight in Western Apache men and Navajo children is consistent with the results of studies on many different populations throughout the world (29). Indeed, the greater secular trend for increasing weight relative to height has been demonstrated for other potentially disadvantaged Americans, namely urban Negro school children (30). In contrast with the North American Indian children, for whom data are available to study the secular trend question, the urban Negro school children have shown a considerable age-specific gain in height for different groups studied between 1890 and 1968. The reasons for this can only be speculated upon, but one prominent possibility is that the improved environmental conditions which allegedly contribute to secular increases in height have been relatively more available to urban Negro school children than to Indian children of similar age. Presumably other factors could explain the difference in secular height trends, including the possibility that the Indian but not the Negro is at or near full genetic height potential.

If it were necessary to make a judgement at this point in time as to whether American Indians share equally in the generally prevalent secular trend in physical growth, the conclusion based on the limited evidence available would be that they probably do not. It seems unlikely that they are at their full genetic height potential, and most observers familiar with environmental conditions affecting American Indians feel there is much room for improvement.

CONCLUSION

More extensive anthropometric study is clearly needed to resolve the degree to which North American Indians and Alaska Natives participate in the secular trend of increasing height and weight. Perhaps of greater importance than documenting the trend in physical growth is the need to determine the factors responsible for the trend. In this context, the supplemental feeding, improved water and sanitation, and other programs contemplated or already introduced, if properly monitored for biologic benefits, may provide the essential information. Alternatively, carefully controlled prospective studies providing medical care,

more and better food, and welfare services may confirm that Indians and Natives have additional height potential which can be expressed under the proper combination of improved environmental conditions.

NOTE: Dr. William Moore was Medical Anthropologist, Growth and Development Branch, National Institute of Child Health and Human Development, Bethesda, Maryland at the time of the Conference. Currently he is Medical Director, Ross Laboratories, Columbus, Ohio 43216.

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CONTEMPORARY NUTRITIONAL STATUS OF NORTH AMERICAN INDIAN CHILDREN

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The North American Indians and Alaska Natives (Eskimos, Indians and Aleuts) are numbered among the disadvantaged minority groups in the United States. Their problems are those of poverty and relative cultural and geographic isolation from the dominant society of this country. However, North American Indians have been dispersing into our society at an increasing rate, becoming diversified both culturally and socioeconomically. Indians who have migrated to the large urban centers often substitute the problems of the urban poor for those of the rural poor. The nutritional status of such a diversified group covers a wide spectrum. Our focus will be on the nutritional status of Indian and Alaska Natives who comprise the service population of the Indian Health Service. For the most part, these are the Indians who reside on reservation land and in Oklahoma and Alaska where there are few reservation boundaries.

Considerable variety exists in the socioeconomic status and cultural heritage of these Indian communities. The differences stem from their particular historical experiences and their geographic location relative to surrounding non-Indian communities. In many respects, Indian reservations can be likened to developing or preindustrial countries of the world. Cultural, geographic and economic factors have isolated the Indian reservations from their non-Indian neighbors over the years just as developing nations have been isolated. The awareness and understand-

ing of both the Indian and his non-Indian neighbor of these problems are combining to produce rapid changes in the lives of reservation Indians. Because nutrition is such an important part of daily life, one could anticipate that the nutritional status of the Indian has been changing fairly rapidly.

This report will assess the many factors involved in food utilization and the effects of this utilization on Indian children. Since data are not available on all the aspects of nutrition covered for each tribal group, the overall picture of Indian child nutrition is like a puzzle with many pieces missing.

SOCIOECONOMIC DATA AND FOOD ECONOMY

In general, the average Indian family of five to six persons is living in poverty with an annual income below $2,000. While many of the families are eligible for welfare payments, these vary from state to state with the size of the family. For example, in Montana the monthly allowance for a family of five is $226 while in Wyoming the maximum grant is $215 for a family of five to seven persons. These payments may be compared with the cost of a nutritionally adequate "low cost food plan" of $131.24 for five persons, which is minimal and requires the use of evaporated milk for infant feeding and infant foods prepared from family table food. Pregnant and lactating women need additional income to meet their nutritional needs. Other states have similarly limited welfare payments which restrict the purchase of adequate diets. Surplus commodities are available from the U.S. Department of Agriculture (USDA) list, but these generally have been limited to flour, cornmeal, milk, lard, butter, rice, beans, pork and gravy, peanut butter, rolled wheat, and cheese.

The 1956-61 Alaska Dietary Survey estimated the average family income of an Alaska Native family to be from $950 to $2,100, depending on the village (1). Many Indian and Alaska Native families live in perpetual debt to the local trader who barters foodstuffs for arts and crafts. This practice is exemplified on the Navajo Reservation where the trader exchanges food and supplies for homemade rugs and/or jewelry. Thus, the trader serves as the marketing and distribution resource for food.

Agricultural statistics of Indian reservations are generally available through the Bureau of Indian Affairs. As might be expected, there is great variation in the methods of food production by the various Indian tribes. Historically, the tribes can be categorized by their basic methods of food procurement. There were the hunters of the plains, the Navajo shepherds, the Pueblo farmers, the Northern fishermen, and the seed gatherers. These descriptions no longer necessarily apply, but they still offer clues in the evaluation of the food economy of Indian tribes. The Arctic Health Research Center's Alaska Dietary Survey in 1956-61 describes in detail the various methods of local food procurement by the

eleven villages studied (1). Since Alaska remains the last frontier, the natives are still able to engage in traditional methods of food procurement, but even this is being curtailed by the pressures of our civilization.

Two extensive surveys done in Montana in 1961 by the Interdepartmental Committee on Nutrition for National Defense and the Division of Indian Health (now called the Indian Health Service) describe the food economy on the Blackfeet and Fort Belknap reservations (2,3). The Blackfeet Indians, who numbered 4,900 in 1960, live on a reservation in Montana with a semi-arid climate and a four-month growing season. They are virtually uninterested in farming, and there were practically no home gardens on the reservation. Irrigated and dryland farming is done on less than 10% of the reservation, while grazing lands occupy over one-half the reservation. Half of the leased land is used by non-Indians, while over 95% of the farmland is used by non-Indians. In 1956, the Blackfoot Indian utilized 2% of his sheep, 14% of his swine, and 65% of his chickens for home use.

The 621,000-acre Fort Belknap Indian Reservation is the home of about 1,300 Gros Ventres and Assiniboine Indians. Most of the reservation is rolling prairie suitable only for grazing with a low average rainfall of 13 inches per year. There is some irrigable land along the Milk River on the north. Non-Indian operators manage larger enterprises on the reservation than the Indians, a situation found on most of the Indian reservations in the prairie states. Indian families under these conditions obtain lease money for the use of their land and rely more on cash for subsistence than on locally produced foods.

The Bureau of Indian Affairs has assisted various tribes in the past in setting up cattle auction pens as a source of marketing for Indian cattle herds. The dryland farmers of the Southwest and other tribes producing their own foods locally have developed systems of preparing and drying their corn, meat, melons, squash, and other foods for storing in family or village storehouses between growing seasons. Incidentally, this practice usually destroys vitamin C.

On most of the reservations and in Alaska, the use of imported foods obtained through the trading posts is becoming a more important, if in some respects a less nutritious, source of diet. The distribution of commodity foods and food stamps is also assuming an important role in the food economy. The food stamp program is available to only a few reservations, but is not generally acceptable because it requires an initial minimal investment of food money by the family and a trip to a distant food stamp purchasing center.

The commodity food program is available for almost all Indians eligible for state welfare. In addition, all Indians receiving health services from the Indian Health Service are eligible for the new USDA Supplemental Food Program for Low Income Groups Vulnerable to Malnutrition, including infants, preschool children, pregnant women, and

women one year post partum. The latter program is presently available in only a few Indian communities excluding Alaska. Both programs are often hindered by distribution problems. Eligible Indian families frequently lack adequate transportation to carry a two- to four-week supply of commodity foods from the distribution centers to their homes. This lack of transportation also hinders many Indian families from shopping in neighboring non-Indian community supermarkets, where prices are lower than on the reservation. They are thus confined to dealing with local traders whose prices are often higher than supermarket prices by 10 to 20% or more.

DIETARY SURVEYS AND NUTRITIVE VALUE OF FOODS

The Alaska Dietary Survey conducted in 1956 to 1961 by the Arctic Health Research Center indicated that an outstanding characteristic of the diets was the extremely wide range of mean daily intakes of all of the major nutrients (Table 1). These intakes were compared with the National Research Council (NRC) Recommended Dietary Allowances, with the following findings:

1. Protein and niacin intakes were generally high because of the larger quantities of fish and meat consumed.
2. The majority of the diets were low in calories, calcium and ascorbic acid.
3. The mean daily intake of iron with few exceptions was adequate-to-high for all age levels beyond infancy. However, one-third or more of the diets for adolescents, pregnant and lactating women, women over 60 years of age, and preschool children in the southwestern area were deficient in iron.
4. Ascorbic acid and vitamin A levels varied with the season and were generally highest in summer and fall, except for the higher ascorbic acid levels found in the school child's diet during the winter.

TABLE 1

Nutrient Intakes on Alaskan Eskimo and Indian Diets of 843 Preschool Children 2 to 6 Years Old (1)

	Mean daily intake	Intake range	Percent under NRC
Protein	94.5 Gm	20.2–324.8 Gm	7.5
Calcium	641 mg	33–2319 mg	85.0
Iron	15.5 mg	1.5–189.0 mg	17.8
Vitamin A	3771 I.U.	40–33064 I.U.	43.0
Thiamine	1.210 mg	.033–5.075 mg	37.5
Riboflavin	1.914 mg	.306–7.483 mg	25.6
Niacin	19.9 mg	1.6–85.5 mg	13.0
Ascorbic Acid	30 mg	0–441 mg	75.8

TABLE 2

Percentage of Diets of Alaskan Natives Containing Average Daily Intakes Below the Recommended Allowance: Nine Nutrients
282 Diets—Formula-Fed Infants— <2 Years By Age Group, All Seasons (1)

Nutrient	Percent Intakes Below NRC Recommended Allowance By Age Group			
	To 5 Mos.	6–11 Mos.	12–17 Mos.	18–22 Mos.
Calories	75.8	82.8	85.8	67.8
Protein			28.2	23.8
Calcium		10.0	39.3	51.1
Iron	100.0	90.0	73.7	48.8
Vitamin A			16.1	20.2
Thiamine	41.3	68.5	69.6	61.9
Riboflavin				7.1
Niacin	72.4	81.4	58.5	40.4
Ascorbic Acid	68.9	87.1	79.7	77.3
Total Number Diets	29	70	99	84

5. The fat content of Eskimo and Indian diets supplied slightly more than one-third of the total calories.

Breast-feeding of infants was common for infants up to two months of age, with formula feeding more common thereafter. A substantial number of infants and children over 12 months of age were being breast or formula fed without supplementation by other foods. Table 2 shows the deficiencies in average daily intakes in the children under two years of age.

The Alaska Native diet is composed of a combination of imported and locally available foods, with the relative importance depending on the geographic location of the village. In general, local foods supplied the protein, iron, vitamin A, riboflavin, niacin and ascorbic acid, while imported foods supplied the carbohydrates, calcium, thiamine, calories and fats.

The changes in dietary patterns of the Alaska Natives over the years have, in general, been characterized by increases in carbohydrate content, the use of largely imported saturated fats, increases in the calcium content due to the increased use of milk, and a reduced use of local foods. The major changes in infant feeding practices include a drastic reduction in number of breast-fed infants and a decreased use of local food resources for infant diet supplementation with more frequent substitution of bread and cereal products.

The Blackfeet Reservation Dietary Survey (2) reported 24-hour recall diet records of 177 families during two survey periods in the autumn of 1961 and the spring of 1962 (Table 3). Twenty-four percent of the in-

TABLE 3

Number of Families with Diet Meeting NRC Recommended Dietary Allowance, Food Studies in the Home, Blackfeet Reservation (2)

Survey period	Autumn 1961					Spring 1962				
Percent of NRC Allowances	(94 families, 538 individuals)					(83 families, 507 individuals)				
	≥100	99–75	74–50	49–25	≤24	≥100	99–75	74–50	49–25	≤24
	Number of families									
Calories	89	3	2			74	5	3	1	
Protein	93	1				79	3	1		
Calcium	40	24	22	7	1	34	18	20	11	
Iron	83	8	3			72	7	4		
Vitamin A	67	6	6	11	4	45	10	12	10	6
Thiamine	93	1				80	2	1		
Riboflavin	90	3	1			69	10	2	2	
Ascorbic acid	33	11	17	21	12	24	19	17	15	8

terviewed school children were considered to have excellent diets, while 58.6% were considered to have poor or very poor diets. Eighty-seven percent of pregnant or lactating women had very poor diets.

The Fort Belknap Dietary Survey obtained 24-hour recall diet records on 113 families and revealed a high protein and calorie intake due principally to the use of large quantities of bread, cereal products, potatoes, meat, and eggs (3). The intake of vitamin A and ascorbic acid was low due to the infrequent use of green and yellow vegetables and fresh fruit. Calcium was also in short supply.

The nutrient analysis of Eskimo diets by the Interdepartmental Committee on Nutrition for National Defense showed that approximately one-third of the daily caloric intake of the village people came from protein, one-third from fat, and one-third from carbohydrates (4).

The Dakota study of eight BIA and parochial boarding schools for Indians, 1959 through 1961, showed that diets of 7- to 8-year-old children were adequate for calories and all nutrients except ascorbic acid (5). The older children showed a low percentage of calories and other nutrients, with niacin and ascorbic acid particularly low. The 12- to 14-year old girls showed a lower mean intake of protein, vitamin A and ascorbic acid than the other children in the school. This was considered an important deficiency since girls of this age are nearing the reproductive period.

The Navajo survey in 1955 showed that most infants were breast-fed, some up to two years. Their diet was supplemented beginning at four to seven months of age, on the average, with evaporated milk, mutton broth, mashed potatoes, mush, coffee or tea, and "pop." It is not uncommon now to see an infant with a nursing bottle full of "pop."

CLINICAL, BIOCHEMICAL AND ANTHROPOMETRIC STUDIES

An important measurement of the nutritional status of a population is the presence of clinical signs and symptoms of malnutrition and vitamin deficiency. In general, most clinical nutrition studies done on Indians have revealed relatively minor findings with very few gross deficiency symptoms or signs. The most prominent finding among Indian children is iron deficiency anemia. In the 1958 survey, 99 Eskimo children two to four years of age were examined and over 90% were judged to have a good general appearance. Less than 10% revealed corneal scarring, slight filiform atrophy of the tongue or geographic tongue. Follicular hyperkeratosis of the skin and some xerosis were also seen in small numbers of children. The Fort Belknap Survey showed a high incidence of diarrhea (81.8%) in the 22 children aged one year to two years old (Table 4), though 91.3% on the total 103 children birth to four years old presented a good appearance. The Blackfeet Survey showed similar findings.

TABLE 4

Clinical Findings in Children 0–4 Years, Fort Belknap Reservation (3)

Age (months)	0–11	12–23	24–35	36–47	48+	Total
Number	21	22	13	28	19	103
	Percent Prevalence					
Diarrhea	23.8	81.8	30.8	39.3	31.6	42.7
Respiratory	23.8	27.2	30.8	28.6	21.0	26.2
Measles		27.2	38.5	42.8	52.7	32.0
Pallor	9.5	4.6				2.9
Poor appearance				3.6		1.0
Fair appearance	14.3	4.6	7.7		15.8	8.7
Good appearance	85.7	95.3	92.3	96.4	84.2	91.3
Dry hair				14.3	5.3	4.9
Conjunctivitis	4.8	9.1			5.3	3.9
Goiter (Grade I)				10.7	5.3	3.9
Protuberant abdomen		4.6				1.0
Splenomegaly		4.6				1.0

Dental surveys were done in conjunction with the nutritional surveys on the Blackfeet and Fort Belknap reservations. Periodontal disease was a major oral health problem and probably was the main reason for the high rate and low age at which teeth were lost. Gingivitis was common in children along with a high rate of debris accumulation which may be associated with peridontal disease later in life. Data from the Phoenix Indian Hospital Dental Department in fiscal years 1967 and 1968 corroborate these findings.

Several biochemical surveys have included Indians, but the numbers of preschool children have been small. The nutritional survey of the Alaska Eskimos in 1958 demonstrated that all of the children had acceptable total serum proteins and hemoglobins (4). Serum vitamin C levels varied quite widely with the lower levels seen in the adults of the southern villages. Serum vitamin A and carotene values were low or marginal primarily in the northern villages. Serum lipids were similar to those of the U.S. white population. The urinary thiamine, riboflavin, and N-methylnicotinamide excretions were in the normal to high range in all the villages. In contrast to the 1958 Eskimo Survey, a study of hemoglobin levels in Kodiak Island children under three years of age revealed an average level, of 10.3 gm/100 ml (8). Thirty-two of the 52 children with hemoglobin levels below 10.5 gm/100 ml had more than two illnesses, while only six of 26 with levels above 10.5 gm/100 ml had more than two infections. Data from the Billings Area show that from 10-20% of preschool children have iron deficiency anemia. A study of iron deficiency anemia in a Pueblo Indian village revealed that 50% of tested

children in the second year of life were hypochromic (7). However, by four years 15% were anemic, and at five years, 10%.

The Blackfeet Reservation survey included biochemical determinations on preschool children which revealed that about one-third were low in hemoglobin, vitamin A, and red cell riboflavin content (2). One-tenth were low in total protein and mean corpuscular hemoglobin. The survey on the Fort Belknap Reservation showed similar biochemical findings in the preschool children (3).

GROWTH OF INDIAN GIRLS, 0-4 YEARS, BLACKFEET RESERVATION

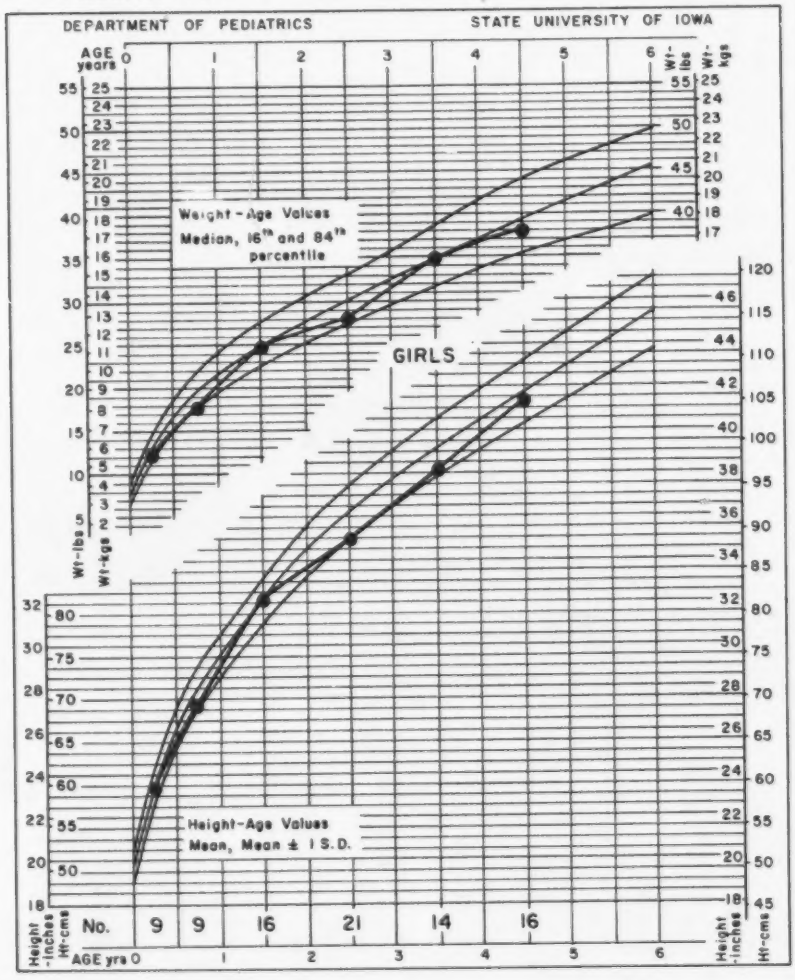

Figure 1: (*From Blackfeet Indian Reservation Nutrition Survey*) (2).

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The ultimate measure of the nutritional status of any group of children is whether they are fulfilling their growth potential. The hereditary factors controlling rate and extent of growth will not be considered here although they are certainly important. A few growth studies of American Indians and Alaska Natives have been done and compared with the standards derived from the Caucasian population in Iowa, Boston, and Canada. One such study on Alaska Eskimos in 1965 demonstrated that

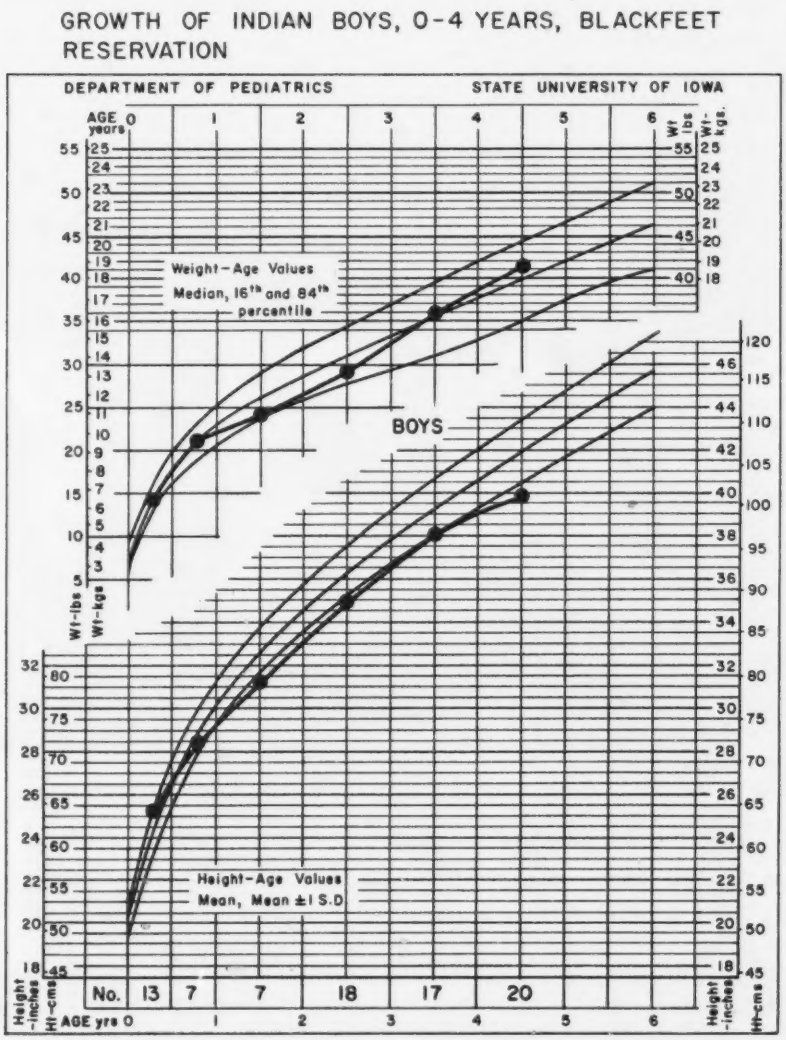

Figure 2: (*From Blackfeet Indian Reservation Nutrition Survey*) (*2*).

newborns had lengths and weights similar to North American white children (9). However, there was a persistently slower rate of postnatal growth leading to a shorter adult Eskimo stature. The average height of the Eskimo children after six months of age was close to the fifth percentile for white children. The ratio of weight to height was consistently higher in Eskimo than in white children.

The Blackfeet Indian Reservation Nutrition Survey analyzed height and weight data of 82 and 85 preschool boys and girls, respectively (2). Figures 1 and 2 show on the Iowa grid the average heights and weights of these children. The growth of the 5- to 14-year-old boys and girls generally followed the 50th percentile line. The growth rates of the Fort Belknap Indians showed similar curves (3). A study of protein and calorie malnutrition among Navajo preschoolers revealed that heights and weights of children in the Head Start programs tended to be low (10). Nearly one-third of the children were below the third percentile on the Boston chart in height, and one-tenth were below the third percentile in weight.

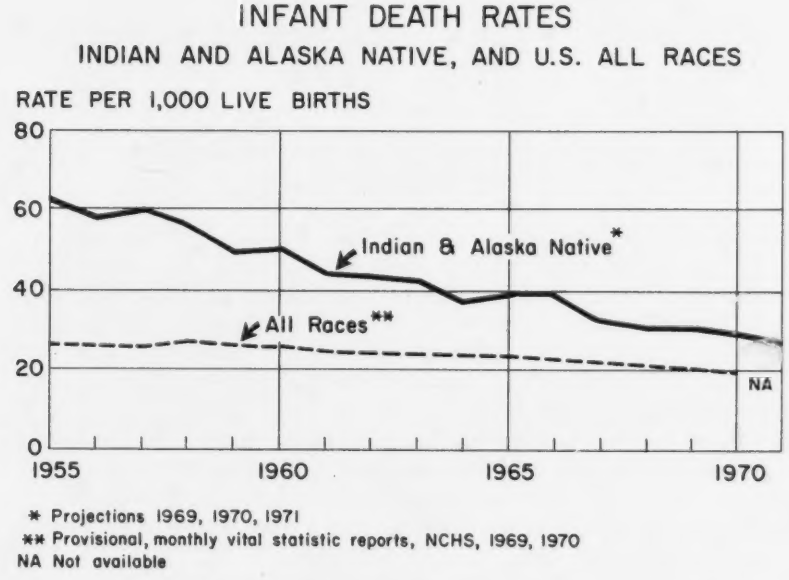

Figure 3: (*From Indian Health Trends and Services, 1970 Ed., PHS Pub. 2092, Washington, GPO, 1971*).

VITAL AND HEALTH STATISTICS

The infant mortality rate and child morbidity rates from infectious diseases and diseases of malnutrition are, in part, a measure of the state of nutrition of a community. Factors such as poor environmental sanita-

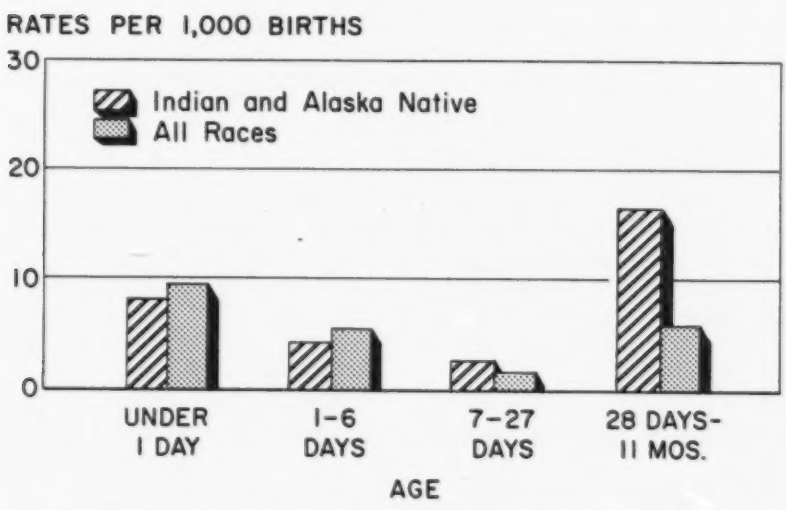

Figure 4: (*From Indian Health Trends and Services, 1970 Ed., PHS Pub. 2092, Washington, GPO, 1971*).

tion also play an important role in infectious disease and infant mortality. The infant mortality rate as shown in Figure 3 indicates a fairly steady improvement in the health and nutritional status of the North American Indian and Alaska Native. Data in the figures refer to calendar years. However, the postnatal infant death rate continues to be higher in Indians than for all races in the U.S. (Fig. 4). This, together with the higher mortality rates in 1- to 4-year-old Indians, suggests that the effects of poor nutrition and environment continue to take their toll in the youngest members of this disadvantaged group. These basic conditions are usually the underlying causes for the respiratory and digestive diseases (primarily diarrhea) which are the immediate causes of infant deaths (Fig. 5).

The Indian Health Service statistics for hospital discharge diagnoses of nutritional deficiencies have shown a steady decline. The figures for fiscal year 1968 appear in Table 5. Of 231 children discharged, there were 31 diagnoses of malnutrition unqualified, nine of kwashiorkor, one of vitamin A deficiency, one of rickets, and one of beriberi. These figures represent primary discharge diagnoses only, and therefore understate the prevalence. Information for the first three months of fiscal year 1969 indicates that primary diagnoses represent

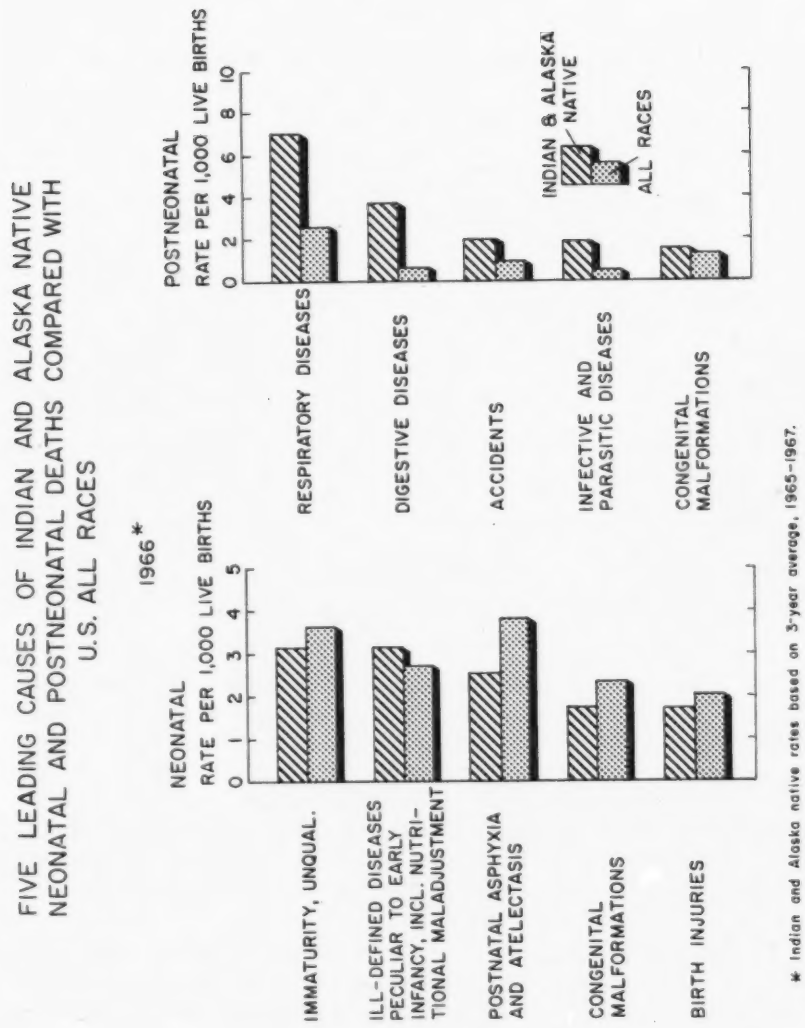

Figure 5: (*From Indian Health Trends and Services, 1970 Ed., PHS Pub. 2092, Washington, GPO, 1971*).

only about 30% of the total number of discharge diagnoses of nutritional deficiencies. It is estimated that the diagnosis of malnutrition was made in 0.25% of all hospital discharges in fiscal year 1966. Outpatient diagnoses are available only for fiscal year 1968 visits to contract physicians. Only 75 outpatient visits for nutritional deficiencies were noted for children under 10 years of age.

The Billings Area inpatient data for one and one-half fiscal years (1968-1969) revealed 31 diagnoses of nutritional deficiency and 341 of

TABLE 5

Number of Discharges from IHS Facilities with a Primary Diagnosis of Nutritional Deficiency, by Age Group (4)

Fiscal Year 1968

Diagnosis	ICDA Code 7th Rev	Total			
		Total	Under Age 1	1–4	5–9
TOTAL		231	187	36	8
Beriberi	280.0	1	1	---	---
Active rickets	283.0	1	1	---	---
Osteomalacia	285.0	1	---	1	---
Steatorrhea & sprue	286.0	2	---	2	---
Vitamin A deficiency	286.1	1	---	---	1
Malnutrition unqualified	286.5	31	6	23	2
Kwashiorkor	286.6	9	2	7	---
Hypocalcemia	286.7	2	2	---	---
Other and multiple deficiency states	286.9	3	1	2	---
Obesity	287.0	6	---	1	5
Nutritional maladjustment	772.0	174	174	---	---

anemia, either iron deficiency or unqualified. A study by Indian Health Service physicians of 24 of the children with nutritional deficiency revealed that about half of them were due to neglect by the mother, who was either alcoholic or incompetent. In one of the other cases, the malnutrition was associated with a cleft palate and in another it was associated with thrush. In many of the cases, malnutrition was associated with an infection, commonly gastroenteric or respiratory. A hospital discharge diagnosis of nutritional anemia was recorded in 10% of preschool children in the Billings Area.

A review of data from the Navajo Area indicated that in fiscal year 1966, of 4,167 hospitalized children under five years old, 72% were infants, of whom 12% had either primary or secondary diagnoses of malnutrition. Twelve percent had anemia (11). In addition, there were 217 hospital discharge diagnoses of malnutrition, including one of kwashiorkor in the birth to 4-year age groups in calendar year 1968. This represented 5.6% of the 3,878 total discharges in these age groups. There were 119 diagnoses of anemia which represented 3.1% of total discharges. In contrast, 26.6% of the discharges were due to diarrhea and enteric diseases.

Information for the calendar years 1963-1967 from the Tuba City service unit of the Navajo Reservation disclosed 28 cases of marasmus and 16 of kwashiorkor, with a total of 15 deaths. In this same period there were 1,455 admissions of children under five years of age with 15%

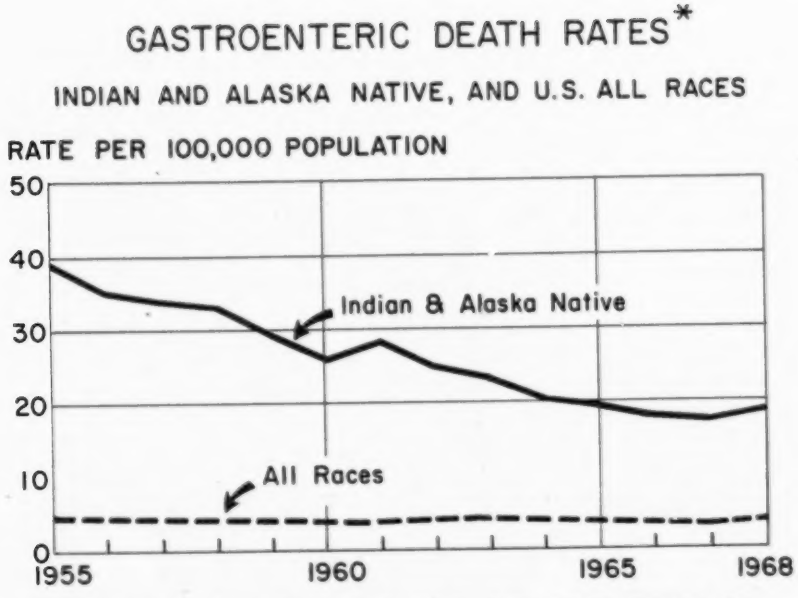

Figure 6: (*From Indian Health Trends and Services, 1970 Ed., PHS. Pub. 2092, Washington, GPO, 1971*).

having some form of malnutrition. Furthermore, this service unit reported 12% of infants severely undernourished with weights less than the third percentile after two months of age. The mean age of the infants with marasmus was 2.2 months with a range of one to seven months. The mean age of the kwashiorkor patients was 14.4 months with a range of five to 30 months.

Information from the Aberdeen Area revealed a high incidence of nutritional anemia in infants and preschool children. Associated with this anemia in infancy and young children was a high incidence of anemia in post-partum women. Information from the Oklahoma Area indicated a relatively low prevalence of malnutrition. The Phoenix Area statistics indicate that primary diagnoses of nutritional deficiencies represented about one percent of all pediatric patients discharged from the hospital.

The high rate of acute infectious diseases would seem to be an indication of nutritional status as well as other factors in the environment of the population. Gastroenteritis, an important infection, has steadily declined since 1955 as shown by the death rate (Fig. 6). However, the higher ratio of gastroenteritis deaths compared with that of all U.S. races--8.5 times as high in the infant and 7.7 times as high in the

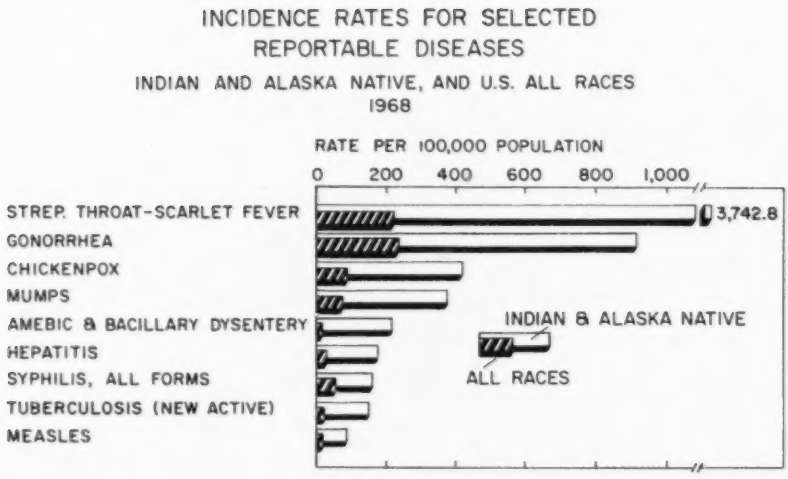

Figure 7: (*From Indian Health Trends and Services, 1970 Ed., PHS Pub. 2092, Washington, GPO, 1971*).

preschool Indian child in 1966--showed the persistence of the problem. The rates per thousand of selected diseases among Indians and Alaska natives compared with those for all races in 1968 are shown in Figure 7 and for the 10 leading reportable diseases in 1968 in Figure 8.

SUMMARY

A review of the nutritional status of American Indian children has been undertaken by examining various factors from the relatively few nutritional surveys and studies that have been done in the past. The data are incomplete, and the picture is changing rather rapidly with the increased interaction between Indians and their non-Indian neighbors. The extent to which these factors have been operative in any one Indian reservation determines the variation in the nutritional status among the many reservation Indians. The following general observations may be made:

1. Socioeconomic data and food consumption patterns reveal that the average reservation Indian family's diet is often marginal and requires supplementation. The deficiencies are generally in animal protein, milk, and fresh fruits and vegetables. These deficiencies mainly contribute to "hidden hunger" which results in the generally poor health of the Indian preschool child. Increased availablity of the attractive carbohydrate foods in the local stores and trading posts on the reservation may contribute to the suboptimal nutrition and the high incidence of dental caries.
2. Nutritional surveys have identified a fairly general dietary deficiency of vitamins A and C, calcium and iron, and borderline protein intake. Protein is more apt to be of the vegetable type and therefore less nutritionally efficient than the animal variety.

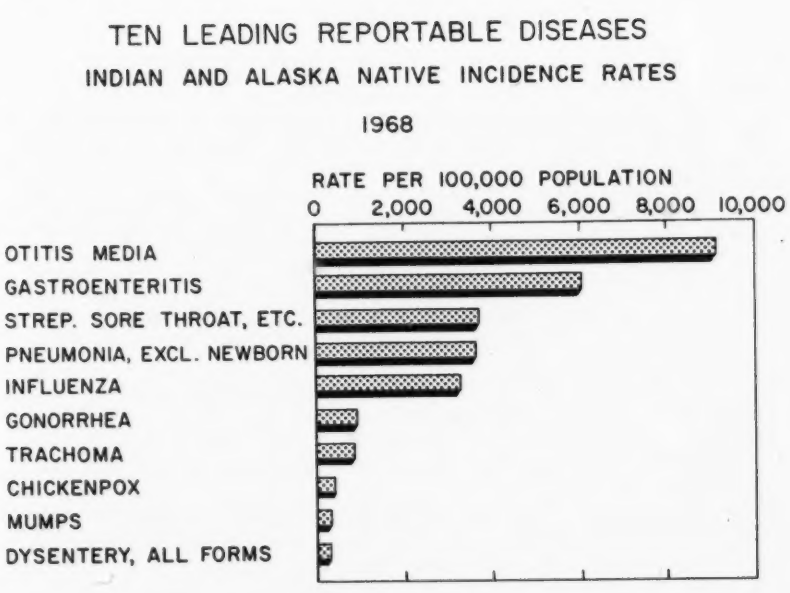

Figure 8: (*From Indian Health Trends and Services, 1970 Ed., PHS Pub. 2092, Washington, GPO, 1971*).

The exception seems to be in the Alaska Natives and Eskimos where one-third of their caloric intake is largely animal protein.

3. Biochemical studies in preschool Indian children are sparse; the most common finding is low hemoglobin levels from iron deficiency anemia.
4. Anthropometric data obtained from a relatively few surveys and few individuals show that the average Indian preschool child is below the average U.S. white child in both height and weight. This lends further credence to the hypothesis that Indian preschool children have suboptimal nutrition.
5. Severe malnutrition is not usually seen on Indian reservations except in association with child neglect which is relatively uncommon. There appears to be a higher incidence of severe protein-calorie and protein deficiency diseases on the Navajo reservation in association with family disorganization and parental lack of knowledge about food and nutrition. The diagnosis of malnutrition is made in only two or three pediatric patients per 1,000 children discharged from Indian hospitals.
6. The high infant mortality and childhood morbidity rates from respiratory and digestive diseases, like the anthropometric data, suggest that the Indian child has a suboptimal nutritional state.
7. Scientific data on the nutritional status of North American Indian children are relatively scarce. Most of the information is indirect, coming from mortality and morbidity statistics. Further and more intensive studies are needed to define the problem accurately.

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NUTRITIONAL SURVEY OF LOWER GREASEWOOD, ARIZONA NAVAJOS

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Relatively little recent information has been published on the nutritional status of the Navajo Indian. However, two studies on Navajo nutrition have been reported. The first, by Darby and co-workers, was carried out in Ganado and Pinon, Arizona in 1956 (1). The second, compiled by McDonald, appeared in 1965 (2). Both of these reports provided helpful background and information for comparison with data obtained in the current survey.

PREVIOUS STUDIES

Darby and colleagues found no frank nutritional deficiency among their sample of Navajo Indians. They concluded there was no problem of anemia or of protein malnutrition and found no active rickets or stigmata of previous vitamin D deficiency in the adults. Nor did they find endemic goiter to a significant extent. Significant fluorosis and severe vitamin B deficiency were not reported.

Darby and his colleagues conceded that oral lesions, the most

prevalent in the population, and conjunctival injection may have indicated the presence of some ariboflavinosis. They found serum ascorbic acid levels below 0.3 mg% in at least half of the population, although scurvy was absent. Vitamin A intake appeared adequate for most people, yet a small percentage of the Navajo sample had low serum levels of this vitamin. Of 760 persons examined, four had unquestionably low serum vitamin A levels and 19 had marginal levels, totaling 3% of the population. Physicians at Sage Memorial Hospital, which serves many Greasewood residents, were reported to have recorded 10 cases of pellagra, two of scurvy, two of beriberi, one of rickets and 97 cases of malnutrition on the basis of 60,000 records examined prior to 1956.

McDonald, on the other hand, reported that 10% of children from birth to four years of age admitted to the Division of Indian Health (now, Indian Health Service) hospitals were "anemic." Fifteen percent of children admitted in early infancy were anemic, and 10% of women giving birth in these hospitals were anemic during pregnancy. She indicated that nutritional diseases constituted the most serious and widespread health threat throughout the Navajo Indian Health Area (NIHA). Further, she suggested that malnutrition was endemic and under-reporting of nutritional diseases was frequent.

Twenty percent of pediatric admissions to NIHA hospitals showed signs of malnutrition according to McDonald's estimates. Two percent of infants admitted were given a primary diagnosis of "malnutrition." She also found that the intake of calcium, vitamin C, iron and riboflavin appeared low, and felt these levels were secondary to consumption of insufficient amounts of lean meat, fresh fruits and vegetables. While the completeness and accuracy of these findings can be questioned for reasons such as Indian distrust of Anglo hospitals, unfamiliarity of staff with symptoms of malnutrition, and others, hospital records show that at least some clinical malnutrition exists on the Navajo reservation.

THE PRESENT STUDY

Consultation between representatives of the National Nutrition Survey, the Indian Health Service, the Lower Greasewood Navajo Tribal Chapter, and the University of Pittsburgh School of Medicine, Department of Community Medicine, led to the conclusion that a study on a limited basis should be carried out. Since the National Nutrition Survey (3) did not include areas where Navajo Indians reside, the present survey was conceived as providing baseline information of value to the Navajos and Federal agencies, including the U.S. Department of Agriculture, in facilitating their efforts to improve nutritional conditions on the reservation.

At the time of the Conference on Nutrition, Growth and Development of North American Indian Children only a brief outline of the present study and incomplete data could be presented. This report, then, is designed to provide a more comprehensive account of the plan and im-

plementation of the survey as well as highlights of the findings. A more detailed report has been prepared by Rogers and Reisinger (4).

OBJECTIVES OF THE STUDY

The Lower Greasewood nutritional survey is best described as a pilot study. While a major objective was to provide information on the nutritional status of groups usually considered vulnerable to nutritional problems, it was fully recognized that procedures commonly employed in the National Nutrition Survey might not be applicable on the Navajo Reservation. Thus, a second important objective was to determine the best procedures for evaluating nutritional status of Navajo Indians on their reservation. For example, there was concern that Navajo families would not participate if the basic approach was on a random selection basis. To satisfy this concern it was concluded that all persons living in a small segment of the reservation should be surveyed rather than individuals or groups from widely scattered parts of the reservation. The survey staff acquired considerable valuable experience working with the Navajos and learned a great deal about factors affecting participation and the acceptability of various types of observations.

SURVEY PROTOCOL AND DEMOGRAPHIC INFORMATION

The area selected for study was the Greasewood Chapter on the Navajo Reservation, about seventy miles from Fort Defiance, with the Chapter center at Lower Greasewood. The Chapter is a political and social unit designated by the Indians. A Bureau of Indian Affairs boarding school and an Indian Health Service clinic are located at the center of the area. The Lower Greasewood Chapter was particularly appropriate for study because of its population, considered to be at risk for nutritional disease, its relative isolation and poor land. Further, the use of its new clinic afforded a means of acquainting the people with the health resources in their chapter.

A modified data collection procedure was carried out from December 1968 to February 1969 using forms from the National Nutrition Survey to record the data. To gain maximum cooperation of the Navajo families, transportation was provided to the clinic in Lower Greasewood. All examinations and collection of samples were performed in the clinic. Only basic household information and names of family members were recorded in the initial home interview.

POPULATION

A Tribal census revealed a Chapter membership of 1,275 individuals comprising 313 family units. A total of 596 (74%) of the 808 persons currently living in the area were examined. Of the 211 family units in the study population, 185 (88%) had at least one member examined. Household information was obtained for all residents.

GEOGRAPHY AND CHARACTERISTICS OF THE AREA

Lower Greasewood is generally considered to extend approximately 100 square miles in a rural, sparsely populated area in northeastern Arizona at an elevation of 5,900 ft. The social and population center of the community is located in an area of one to two square miles which contains a trading post, the Indian Health Service Clinic, a government boarding school and a group of about 40 modern houses for government workers, most of whom are Navajo.

A paved road leads into the community from the north. A graded road, passable year round, extends southwest from Greasewood to Holbrook, Arizona, 50 miles away. Most of the people live and raise their sheep in the valley one to two miles wide. A few live on the plateaus on either side of the valley. The population is concentrated along the western border of the valley stretching about seven miles away from the trading post and school. Areas of lighter population density are found in the south.

SOCIOECONOMIC CHARACTERISTICS

The Navajo Indians in Lower Greasewood represent a unique blend of cultures, including Spanish, Indian, and Anglo (white, English-speaking American). Education, familiarity with Anglo culture, and ability to speak English vary from little or none to a high degree. While the religion, feeding patterns and beliefs reflect the Navajo culture, they also vary greatly.

Social units consist of camps or extended families, often matrilocally based. The families live near each other in hogans, sandstone houses and other types of housing. Fifty-two houses in Greasewood are part of a Public Health Service project and have running water and modern sanitation. However, electrical power is uncommon and based on proximity to the few power lines.

The prime staples are sheep and corn. Each family has a flock of sheep, used as a main source of meat as well as income. Depending on the size of the flock and general financial situation, the sheep are butchered for family consumption. Most families continue to eat at least some native plants such as wild spinach, cactus fruit, wild onion, wild rhubarb, pinon nuts and yucca fruit. The pinon nut has a high fat content, and there is abundant vitamin C in cactus fruit. Small game is scarce in the Lower Greasewood area.

The majority of children in Greasewood attend school; those from 4 to 13 years of age attend the boarding school in Greasewood. About half of these children (boarding students) receive all their meals in school, while the others (day students) eat only lunch. About 25 children go to Ganado Public School. Once past the eighth grade, most students are sent to boarding schools throughout the reservation or to off-reservation schools.

For Greasewood, as for much of the rest of the Navajo Reservation, few economic or demographic data exist. No median income has been computed. The main sources of income are sheep and goat herding, gardening, and jobs in other reservation or off-reservation areas. Men are commonly away from home, returning only for weekends or holidays. Welfare, surplus, and odd jobs such as rug weaving contribute to the economy of the area. Of the approximately 350 families, 63 are on state or Bureau of Indian Affairs (BIA) welfare.

HEALTH CARE

Prior to the opening of the Indian Health Service Clinic in Greasewood in 1968, most residents traveled 25 to 75 miles for health care. A Presbyterian hospital (Sage Memorial) is located in Ganado, Arizona, 25 miles away, and the Public Health Service Indian hospital in Fort Defiance is 75 miles away. Lack of transportation to these facilities has limited their use by the Greasewood populace. Since the clinic was opened in 1968 with a full-time Indian Health Service physician, a high percentage of patients are now being seen there first. Trachoma, impetigo, and diarrhea are still widespread throughout the community. Tuberculosis is not frequently seen, a change from earlier health reports of the area. Many Navajos rely on the community medicine man to cure their ills. They generally feel that both types of medicine offer something, but the white man's way still plays the smaller role.

STUDY METHODS

Planning

A list of residents was drawn from the Chapter census, the Public Works census, and records of the Ft. Defiance Land Management Office of the BIA. Navajo driver-interpreters native to the region worked with project personnel to find all the residences in the area. After planning and working closely with Chapter representatives, home visits were made with the Navajo driver-interpreters to about 50 camps in the Greasewood area.

Field workers from both the Tribe and the Office of Navajo Economic Opportunity Community Development provided valuable help, and as many Tribal members as possible from the area were hired, including technical assistants, driver-interpreters, interviewers, and community liaison workers.

Procedures

Four types of data were collected: 1. Demographic; 2. Dietary, including food purchase, preparation and storage; 3. Clinical history and examination; and 4. Laboratory determinations.

Demographic data were collected by the four Navajo driver-interpreters when they visited each household to invite families to par-

ticipate, or by the clinic personnel when individuals appeared for their nutrition appraisal. A modified version of the National Nutrition Survey Household Information Form was used (4).

Information forms about food were prepared by Mrs. Barbara McDonald of the Indian Health Service, and interviews were held with women who came to the Greasewood clinic for the survey examination. The interviews were conducted by specially trained, local Navajo women who completed one form for each household. Special forms were prepared for pregnant and lactating women and children under six years old based on the family cook's information.

Clinical history and examination data were collected on National Nutrition Survey Forms II, III, IV, and V (5). Measures of height, weight and triceps skinfolds were obtained on all subjects, and head circumference was determined on children under three years old. Criteria for clinical evaluation matched those outlined in the Interdepartmental Committee on Nutrition for National Defense Manual for Nutrition Surveys (6) and the National Nutrition Survey Guidelines and Procedures (5).

Laboratory specimens were obtained at the time of clinical examination. Blood samples were collected from all subjects except a few males during the first days of the program. Random voided urine specimens were also obtained on all subjects at the time of examination. Hemoglobin and hematocrit determinations were made at the Greasewood clinic. Part of the blood sample was centrifuged and the serum separated while the remainder of the sample was placed in a heparinized tube. All blood and urine specimens were frozen within one hour of collection and shipped in dry ice within 72 hours to the U.S. Army Medical Research and Nutrition Laboratory, Fitzsimmons General Hospital, Denver, Colorado. Serum vitamin A, vitamin C, iron, total protein, transferrin saturation, and total iron binding capacity were determined, as well as urinary riboflavin, thiamin and total solids.

All subjects under 18 and not pregnant underwent an X-ray of their left hand and wrist. The films were developed and interpreted by Dr. Stanley Garn and associates at The Center for Human Growth and Development, University of Michigan.

FINDINGS

Demographic and Socioeconomic

The results of the nutrition survey are based on household information from 996 Chapter members and on clinical and laboratory examinations of 596 Greasewood residents.

Age and Sex Distribution of the Population

Of persons about whom household information was available, 494 were male and 498 were female; the sex of the remaining four was not

recorded. The median age for both males and females was 16 years, and approximately equal numbers of males and females fell into each age group. More females (313) were examined than males (274). Children and persons 45 years and over had the highest percentage of examinations. Only one-third of the persons 17 through 44 years were examined, most of whom were women.

Family Size

The average family size was 5.5 members (996/181). Of the 996 persons about whom information was available, family status was: family head, 181; spouse, 127; child, 638; stepchild, 25; unclassified, 25. The larger number of family heads than spouses was accounted for by widows, widowers, unmarried and divorced persons.

Geographic Distribution

Of the 980 persons about whom geographic information was obtained, approximately 40% lived five or more miles from the clinic and trading post. Participation in the nutrition survey and examination was least in the area immediately surrounding the health center. The low rates of examination of Navajos living in Greasewood reflected the fact that the offer of a complete medical appraisal, including transportation to and from the clinic, was not as attractive to people who lived within easy reach of the clinic and used it frequently as it was to persons living farther away.

Number of Rooms

About 44% of the population identified lived in a one-room house, the traditional hogan. Twenty-nine percent lived in two-room houses which were also generally primitive. The remaining 27% lived in houses with three or more rooms, which were mostly in the immediate vicinity of the clinic, trading post and school and had been constructed by the BIA for teachers and aides at the boarding school.

Sanitary Facilities

Thirty-five percent of the 996 persons lived in dwellings with no special sanitary facilities. Another 41% lived in homes with poorly constructed outhouses. Only 22% resided in homes with indoor toilets; these were located almost entirely in the area adjacent to the clinic and trading post. Most of the one- and two-room houses had no inside toilet, whereas almost all houses of four or more rooms did.

Water Supply

Few families had wells adjacent to their homes. Water was obtained from shallow wells, usually some distance from the houses. About

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30 families to the south of the clinic had piped water, but consumption was limited because of the bad taste.

Education and Employment

Of the 457 persons 20 years or older, 28% of the men and 43% of the women had had no schooling, and 22% of the men and 19% of the women had completed only five to eight grades of school. Nearly 50% of adults reported attending four years of school or less. When the adult population was subdivided by age, the lowest levels of education were found in the oldest groups.

Of the 400 persons 17 years and older about whom information was obtained regarding work status, 36% of the men and 69% of the women were unemployed. Forty-one percent of the men worked less than full-time on a year round basis. Of the unemployed and partially employed men, 56% claimed no work was available.

DIETARY PATTERNS

Food was obtained from three main sources in Greasewood: home production, including sheep, corn and other family crops; the Greasewood Trading Post and the supermarket which opened in late 1968, 75 miles away; and the government commodity program. Almost three-quarters of the population (71%) raised some of their own food. The trading post carried no whole milk nor fresh fruits or vegetables, though the majority of residents used the trading post because of lack of transportation to other facilities. Over half the households (53%) received commodity foods at the time of the survey. Only 21% of households had running water, 23% electricity, and 23% refrigeration. Meat was generally stored outside (75%).

Weekly expenditures for food increased somewhat as household size increased. However, per capita food expenditures decreased markedly as household size increased. For example, households of three, four and five members reported weekly per capita food spending at a rate of $7.00, $5.27, and $4.54, respectively. When family size increased to seven, eight, nine or more persons, weekly per capita food expenditures fell to $3.44, $2.73, and $2.99, respectively (4). However, households above the median size were not more likely than those below to receive commodity foods nor to raise their own food.

The modified dietary recall procedure was completed by 135 females. Milk was not consumed regularly and fruit or fruit juice was taken by only part of the group. When absolute intakes were calculated, it appeared that the basic diet was not grossly deficient. Based on biochemical analyses in the older population, nutritional deficiencies may be related to insufficient intake of vitamin C.

Infant Feeding

Information on the feeding of 24 children under two years of age

showed that the majority were bottle-fed, i.e., breast feeding with and without supplementation was practiced only in slightly over one-third of these infants. The use of milk or milk-based formula was highest in children under three years of age. However, milk was reported to be used less frequently in children by age three years, and over one-half of children from three to six years were reported to have consumed no milk in the 24-hour recall period.

Malnutrition often is the product of poor usage of available foods because of taboos and prejudice. Among the Navajo, children often are given soft drinks and coffee rather than milk because milk is thought to be a "weak food" not good for growing children, and because it is thought to cause diarrhea.

The use of supplemental vitamins in children was very limited with only 12% under six years of age reported to have taken them.

CLINICAL FINDINGS

Pediatric Histories

At the time of examination the clinical histories of 108 children under six years of age were obtained from the parent accompanying the child. Two children were said to have defects of the mouth and one an eye defect the nature of which were not described. About one-quarter of the children were reported to have had measles; one-third, chicken pox; and three, mumps. Eight children were said to eat soil. Seventeen children had experienced serious accidents, including 4 burns, 2 automobile accidents and 11 falls.

One third of the children were said to have had diarrhea one or more times during the six months preceding the examination. Five had diarrhea at the time of examination. Six had experienced two episodes of diarrhea in the preceding six months and another six children had undergone three to five episodes during the same period. However, when sanitary and refrigeration facilities, size of house, and the years of schooling of the household head were examined in relation to the number of episodes of diarrhea, no significant association was found (4).

Skin

With the exception of dryness or scaling, no important lesions of the skin were found. The dry climate and exposure to wind and sand make this finding of dubious signficance.

Eyes

No Bitot's spots, circumcorneal injection, xerosis conjunctivae, keratomalacia, or xerophthalmia were seen. No determination was made regarding nightblindness. About six percent of those examined had conjunctival injection, but with wind and sand this may be expected. Many

cases of trachoma--both acute and chronic--were seen. Traumatic loss of one eye was also seen in a number of persons. Extensive pterygium was present in all persons over thirty years of age.

Lips

The presence of angular lesions in 3% of the adult population and 3% of the pediatric group combined with the existence of angular scars in 11% of those six years and older may indicate the presence of riboflavin deficiency. Males outnumbered females quite significantly in these categories.

Teeth

Fluorosis of the teeth was found in 31% of adults and 6% of children under six years. Many persons over eighteen were missing two to four teeth, but according to the Indian Health Service Dental Officer in Greasewood, this is probably due to poor hygiene. Of adults, 6% were edentulous and 1% had plates. Stigmata of corrected cleft palate were seen in one individual.

Gums

Marginal redness (local and diffuse) was found in 19% of adults and in 1% of children. Males and females were about equal in this category with all age groups represented. Atrophy, recession, or inflammation (local and diffuse) were seen in 3% of adults. Swollen red papillae (local and diffuse) were seen in 7% of adults and 1% of children. Bleeding gums were seen in 1% of Greasewood adults. There were no signs of scurvy.

Tongue

Filiform atrophy was seen in 7% of adults and 2% of children. No children under six years of age had other tongue lesions. Only one older person had fungiform papillary hypertrophy, one had glossitis, and two had serrations or swelling. No cases of magenta tongue were seen in Greasewood.

Thyroid

Thyroid enlargement was seen in 2% of children under six years and 13% of persons six years of age and older. While no classic goiters were observed, four persons (1%) had glands that were apparent on casual glance. In 4% of the population, glands could be seen with the neck in full extension. Most of the lesions (57%) occurred in females. In the males, 16 of the 19 lesions were found in the 6- to 19-year-old age group.

Lower Extremities

There were four cases of bilateral pretibial edema in the adults (1%) and none in the children. There was only one case of calf tenderness.

Blood Pressure

A higher prevalence of hypertension was found in persons 20 years and older than has been reported previously; 13% of males and 6% of females over age 20 had a diastolic pressure greater than 100 mm Hg. Prevalence was not age associated. When pressures were considered elevated, three or more determinations were made and the median selected.

Pregnancy and Lactation

Of the 19 women who were either pregnant, lactating, or both, there were 5 with palpably enlarged thyroids (26%), 8 cases of local and diffuse marginal redness of the tongue (42%), 4 cases of swollen red gum papillae (21%), 1 case of bleeding gums, 2 cases of spooning of the finger nails, and 1 case of mild filiform atrophy of the tongue. There were 2 cases of seborrhea.

LABORATORY FINDINGS

Hemoglobin and Hematocrit

The standards used for hemoglobin and hematocrit values were those of the National Nutrition Survey corrected for the altitude at which the Greasewood population lived by adding approximately 2.0 gm % to the hemoglobin and seven points to the hematocrit values. These values were used for developing the columns marked "Below Navajo Deficient" in Tables 1 and 2.

On the basis of hematocrit levels, 16% of males and 11% of females in the Greasewood population had values below the altitude-modified National Nutrition Survey Standards (Navajo deficient level). Almost all persons found to have low values for hematocrit were over 12 years. Of women between 17 and 44 years, 20% were in the low category. This figure fell to 11% for those 45-64 years and 7% for females 65 years and over. For males, 65 years and older, 29% had low values.

Based on hemoglobin levels, 17% of the Greasewood population had values below Navajo deficient--8% of males and 9% of females. While some low hemoglobin levels were seen in children, low levels occurred more frequently in persons over twelve years of age.

Serum folic acid and red cell folic acid levels were determined for most of the blood samples. Very few low or deficient values were found (less than 1%) suggesting that the low hemoglobin levels were not the result of low folate intake.

TABLE 1 (4)

Hemoglobin

Age	Number	Mean %	Range %	Below Navajo Deficient		Below NNS Acceptable		NNS Deficient	
				#	%	#	%	#	%
Male									
<6 months	2	11.3	10.5–12.0	—	—	—	—	—	—
6–23 months	9	12.6	10.5–16.0	1	11	0	0	0	0
2– 5 years	40	13.9	11.0–18.2	2	5	0	0	0	0
6–12 years	98	13.5	11.5–17.2	2	2	0	0	0	0
13–16 years	30	14.4	13.2–16.2	10	33	0	0	0	0
17–44 years	39	16.1	13.2–19.0	1	3	1	3	0	0
45–64 years	33	15.1	9.8–17.9	5	15	5	15	2	6
≥65 years	18	15.2	13.7–18.0	1	6	1	6	0	0
Total	269	14.3		22	8	7	3	2	0.7
Female—Nonpregnant, Nonlactating									
<6 months	4	12.9	11.3–14.5	—	—	—	—	—	—
6–23 months	8	11.9	10.0–14.7	2	25	0	0	0	0
2– 5 years	31	13.3	10.5–15.0	3	10	1	3	0	0
6–12 years	101	13.5	10.8–17.7	8	8	3	3	0	0
13–16 years	34	13.8	10.3–16.8	2	6	2	6	0	0
17–44 years	50	14.0	9.0–17.2	7	14	7	14	1	2
45–64 years	44	14.2	10.8–16.2	3	7	3	7	0	0
≥65 years	15	14.0	10.9–15.5	1	7	1	7	0	0
Total	287	13.7		26	9	17	6	1	0.3

NATIONAL NUTRITIONAL SURVEY STANDARDS

Hemoglobin (g/100 ml)	*Deficient*	*Acceptable*
6–23 months	< 9.0	≥10.0
2– 5 years	<10	≥11.0
6–12 years	<10	≥11.5
13–16 year male	<12	≥13.0
13–16 year female	<10	≥11.5
>16 year male	<12	≥14.0
>16 year female	<10	≥12.0
Pregnant, 2nd Trimester	< 9.5	≥11.0
Pregnant, 3rd Trimester	< 9.0	≥10.5

TABLE 2 (4)

Hematocrit as Percentage

Age	Number	Mean %	Range %	Below Navajo Deficient #	Below Navajo Deficient %	Below NNS Acceptable #	Below NNS Acceptable %	NNS Deficient #	NNS Deficient %
Male									
<6 months	2	43	42–44	0	0	0	0	0	0
6–23 months	10	37	34–39	1	10	0	0	0	0
2– 5 years	40	40	35–45	5	13	0	0	0	0
6–12 years	99	40	33–47	4	4	2	2	0	0
13–16 years	30	43	39–48	16	53	3	10	0	0
17–44 years	39	47	29–52	6	15	6	15	1	3
45–64 years	33	45	32–51	7	21	7	21	1	3
≥65 years	17	45	40–52	5	29	5	29	0	0
Total	270	42		44	16	23	9	2	0.7
Female, Nonpregnant, Nonlactating									
<6 months	4	41	36–49	0	0	0	0	0	0
6–23 months	10	37	33–41	0	0	0	0	0	0
2– 5 years	32	39	32–43	6	19	1	3	0	0
6–12 years	101	40	29–48	8	8	4	4	1	1
13–16 years	33	41	35–45	2	6	1	3	0	0
17–44 years	50	41	33–48	10	20	10	20	0	0
45–64 years	45	42	32–48	5	11	5	11	0	0
≥65 years	15	41	31–45	1	7	1	7	0	0
Total	290	36		32	11	22	8	1	0.3

NATIONAL NUTRITION SURVEY STANDARDS

Hematocrit (%)	*Deficient %*	*Acceptable %*
6–23 months	<28	≥31
2– 5 years	<30	≥34
6–12 years	<30	≥36
13–16 years male	<37	≥40
13–16 years female	<31	≥36
>16 years male	<37	≥44
>16 years female	<31	≥38
Pregnant, 2nd Trimester	<30	≥35
Pregnant, 3rd Trimester	<30	≥33

TABLE 3 (4)

Serum Iron

Age	Number	Mean ug/100 ml	Range ug/100 ml	Below NNS Less Than Acceptable	
				#	%
Male					
<6 months	0	—	—	—	—
6–23 months	1	25	25	1	100
2– 5 years	12	59	30– 95	2	17
6–12 years	43	76	7–195	7	16
13–16 years	11	107	51–162	1	9
17–44 years	10	88	6–187	3	30
45–64 years	11	90	32–138	3	27
≥65 years	5	96	52–132	1	20
Total	93	81		18	19
Female—Nonpregnant, Nonlactating					
<6 months	0	—	—	—	—
6–23 months	0	—	—	—	—
2– 5 years	11	83	30–161	3	27
6–12 years	40	87	38–141	9	23
13–16 years	14	65	20–141	3	21
17–44 years	24	64	10–162	7	29
45–64 years	22	62	4–138	7	32
≥65 years	5	98	73–160	0	0
Total	116	75		29	25

NATIONAL NUTRITIONAL SURVEY STANDARDS

Serum iron ug/100 ml	*Less than Acceptable*	*Acceptable*
6–23 months	<30	≥30
2– 5 years	<40	≥40
6–12 years	<50	≥50
≥13 years male	<60	≥60
≥13 years female	<40	≥40

Serum Iron

Two hundred and nine samples were taken at random from the total samples drawn (209 of 596). Forty-seven of the 209 (23%) were found to have low serum iron levels, mainly in the population over 17 years of age (Table 3). All age groups had a significant proportion of low values, but this proportion tended to increase with age.

Transferrin Saturation

Abnormal values were those where the percent transferrin saturation was less than the National Nutrition Survey standard (Table 4). One hundred and eighty-eight samples were tested: 70 (37%) had reduced percent transferrin saturation.

TABLE 4 (4)

Transferrin Saturation

Age	Number	Mean %	Range %	Below NNS Less Than Acceptable	
				#	%
Male					
<6 months	0	—	—	—	—
6–23 months	0	—	—	—	—
2– 5 years	6	20	10–27	3	50
6–12 years	41	21	4–54	21	51
13–16 years	9	30	19–44	2	22
17–44 years	9	26	3–49	3	33
45–64 years	11	27	11–41	3	27
≥65 years	5	26	12–32	1	20
Total	81	24		33	41
Female—Nonpregnant, Nonlactating					
<6 months	0	—	—	—	—
6–23 months	0	—	—	—	—
2– 5 years	8	25	10–57	3	38
6–12 years	37	25	11–43	11	30
13–16 years	14	18	5–39	5	36
17–44 years	23	18	5–45	10	43
45–64 years	21	19	1–40	8	38
≥65 years	4	27	17–35	0	0
Total	107	22		37	35

NATIONAL NUTRITION SURVEY STANDARDS

Transferrin Saturation (%)	*Less than Acceptable*	*Acceptable*
6–23 months	<15	≥15
2– 5 years	<20	≥20
6–12 years	<20	≥20
≥13 years male	<20	≥20
≥13 years female	<15	≥15

The majority of Navajo children seen at Greasewood were not suffering from iron deficiency anemia and appeared to be healthier than some other low-income groups in the United States. Nevertheless, 22 of 107 (26%) children under 13 years of age had low serum iron and 38 of 92 (41%) of this group had less than acceptable transferrin saturation. The presence of low hemoglobin levels in the menstruating female population and older males, and low serum iron and high TIBC levels, probably indicated low iron intake in these groups.

Ascorbic Acid

Serum ascorbic acid levels were determined on 430 samples (Table 5). Values below 0.20 mg% were considered less-than-acceptable for all age groups. The median value for all persons was 0.82 mg%, with only 23 values less than 0.20 mg%. The unacceptable values comprised 5% of the total sample tested, and occurred mainly in older age groups.

TABLE 5 (4)

Serum Vitamin C Levels

Age	Number	Mean mg/100 ml	mg/100 ml Range
Male			
<6 months	0	—	—
6–23 months	0	—	—
2– 5 years	23	0.9	0.2–1.6
6–12 years	90	1.0	0.2–1.8
13–17 years	28	0.9	0.3–1.8
18–44 years	32	0.5	0.2–1.3
45–64 years	23	0.4	0.1–1.2
≥ 65 years	14	0.6	0.1–2.0
Total	210	0.8	
Female—Nonpregnant, Nonlactating			
<6 months	0	—	—
6–23 months	0	—	—
2– 5 years	18	0.9	0.1–1.7
6–12 years	91	1.0	0.2–1.2
13–17 years	32	1.1	0.2–2.0
18–44 years	34	0.6	0.2–1.6
45–64 years	35	0.6	0.1–2.0
≥ 65 years	10	0.2	0.1–2.0
Total	220	0.8	

Vitamin A

Four hundred thirteen of the 596 samples were chosen in a random fashion for determination of vitamin A levels. Plasma vitamin A levels of less than 20 ug/100 ml were considered unacceptable. Four of the 420 samples were in this category. The mean level of vitamin A was 52 ug/100 ml; thus insufficient vitamin A intake was not a problem in this population. All individuals with low vitamin A had normal hemoglobin, hematocrit, and vitamin C levels.

Urinary Riboflavin and Thiamine Excretion

No deficient excretion levels were found for thiamine and only one for riboflavin in approximately 500 samples analyzed. The mean value for riboflavin excretion was 1,086 ug/gm of creatinine, and for thiamine, 1,331 ug/gm of creatinine.

Serum Protein

Serum protein determinations were made on 459 samples of which 11% of males and 14% of females had values below the National Nutrition Survey acceptable levels. Most of the low values occurred in persons 17 years and older.

ANTHROPOMETRIC MEASUREMENTS

Height and Weight

For ages from birth through 14 years, heights and weights of children were classified according to the Boston and Iowa growth standards (7). For adults, standards from the National Health Examination Survey were used (8). Tables 6 and 7 indicate the distribution of height of Greasewood children and adults. All age-sex groups except males 40 years and older had a moderate to substantial excess of persons below the 50th percentile. Boys and girls appeared approximately equally affected whereas women seemed to be more affected than men.

While the Navajos sampled may be shorter than U.S. standards for nutritional or other environmental reasons, the differences may be genetic. In general, there is little information on ethnic differences under varying environmental conditions, but feeling among many physical anthropologists, nutritionists and physicans is that environmental factors play a greater role in determining the tempo of skeletal maturation and probably adult height than genetic ones (9,10).

Tables 8 and 9 present the distribution of weight of Greasewood children and adults. As with height, there was an excess of children below the 50th percentile for weight. However, only women over 50 years had an excess proportion of their number below the 50th percentile; women 18-50 years of age had an excess proportion above the 50th percentile for weight.

TABLE 6 (4)

Lower Greasewood Nutrition Study
Height of Navajo Children

Percentile	Male										Female									
	Age in Years										Age in Years									
	0–1		2–4		5–9		10–14		Total		0–1		2–4		5–9		10–14		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Below 3	6	40	17	51	13	19	5	10	41	24	3	20	9	43	10	14	8	15	30	19
3–9	1	7	6	18	15	22	13	25	35	21	3	20	6	29	17	24	13	24	39	24
10–24	2	13	2	6	20	29	9	18	33	20	0	0	1	5	17	24	11	20	29	18
25–49	2	13	2	6	13	19	13	25	30	18	4	27	5	24	11	16	14	26	34	21
50–74	0	0	1	3	6	9	4	8	11	7	2	13	0	0	11	16	5	9	18	11
75–89	2	13	1	3	1	1	2	4	6	4	0	0	0	0	4	6	2	4	6	4
90–96	0	0	1	3	0	0	0	0	1	0	2	13	0	0	0	0	0	2	2	1
97 and >	2	13	3	9	1	1	5	10	11	7	1	7	0	0	1	1	1	0	3	2
Total	15		33		69		51		168		15		21		71		54		161	
Percentage below 50th percentile		73		81		89		78		83		67		100		77		85		82

TABLE 7 (4)

Lower Greasewood Nutrition Study
Height of Navajo Adults

Percentile	Male										Female									
	Age in Years										Age in Years									
	18–29		30–39		40–49		50 and >		Total		18–29		30–39		40–49		50 and >		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Below 5	1	8	4	24	0	0	2	5	7	6	1	4	5	17	6	22	6	11	18	14
5–9	0	0	3	18	4	17	5	12	12	13	4	17	5	17	1	4	3	6	13	10
10–19	0	0	2	12	1	4	3	7	6	6	4	17	5	17	3	11	14	26	26	20
20–29	2	17	1	6	1	4	4	9	8	8	5	22	6	21	8	30	11	21	30	23
30–39	1	8	2	12	6	25	5	12	14	15	0	0	0	0	1	4	6	11	7	5
40–49	5	42	0	0	1	4	4	9	10	10	5	22	3	10	2	7	3	6	13	10
50–59	1	8	3	18	5	21	4	9	13	14	3	13	4	14	3	11	4	8	14	11
60–69	0	0	0	0	3	13	4	9	7	7	0	0	0	0	2	7	2	4	4	3
70–79	0	0	1	6	2	8	4	9	7	7	1	4	0	0	0	0	1	2	2	2
80–89	2	17	1	6	0	0	6	14	9	9	0	0	0	0	0	0	1	2	1	1
90–94	0	0	0	0	1	4	1	2	2	2	0	0	1	3	1	4	1	2	3	2
95 and >	0	0	0	0	0	0	2	5	2	2	0	0	0	0	0	0	1	2	1	1
Total	12		17		24		44		97		23		29		27		53		132	
Percentage below 50th percentile		75		70		46		53		59		82		83		78		80		80

TABLE 8 (4)

Lower Greasewood Nutrition Study
Weight of Navajo Children

Percentile	Male										Female									
	Age in Years										Age in Years									
	0–1		2–4		5–9		10–14		Total		0–1		2–4		5–9		10–14		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Below 3	6	43	6	20	11	16	8	15	31	19	1	7	3	15	8	11	5	9	17	11
3–9	3	21	5	16	11	16	6	11	25	15	3	21	4	20	11	15	6	11	24	15
10–24	2	14	6	20	18	26	9	17	35	21	2	14	5	25	10	14	19	35	36	22
25–49	0	0	5	16	15	22	14	26	34	20	2	14	4	20	21	29	13	24	40	25
50–74	0	0	2	6	11	16	11	21	24	14	2	14	4	20	14	19	6	11	26	16
75–89	1	7	2	6	2	3	1	2	6	4	2	14	0	0	5	7	4	7	11	7
90–96	1	7	1	3	1	1	1	2	4	2	1	7	0	0	1	1	0	0	2	1
97 and >	1	7	4	13	0	0	3	6	8	5	1	7	0	0	3	4	1	2	5	3
Total	14		31		69		53		167		14		20		73		54		161	
Percentage below 50th percentile		78		72		80		69		75		56		80		69		79		73

TABLE 9 (4)

Lower Greasewood Nutrition Study
Weight of Navajo Adults

	Male										Female									
	Age in Years										Age in Years									
	18–29		30–39		40–49		50 and >		Total		18–29		30–39		40–49		50 and >		Total	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Below 5	3	23	0	0	3	13	2	5	8	8	1	4	2	7	3	11	8	15	14	11
5–9	0	0	0	0	1	4	6	14	7	7	0	0	0	0	2	7	6	11	8	6
10–19	2	15	6	36	3	13	7	16	18	18	1	4	1	3	0	0	5	9	7	5
20–29	4	31	1	6	4	17	6	14	15	15	2	9	0	0	0	0	7	13	9	7
30–39	0	0	4	24	6	25	5	11	15	15	4	17	3	10	3	11	4	7	14	11
40–49	0	0	2	12	2	8	3	7	7	7	1	4	2	7	0	0	6	11	9	7
50–59	0	0	0	0	2	8	2	5	4	4	1	4	2	7	3	11	8	15	14	11
60–69	1	8	2	12	0	0	5	11	8	8	1	4	6	21	7	26	7	13	21	16
70–79	0	0	1	6	2	8	2	5	5	5	3	13	5	17	2	7	0	0	10	8
80–89	2	15	0	0	0	0	5	11	7	7	5	22	5	17	4	15	3	6	17	13
90–94	1	8	1	6	0	0	1	2	3	3	1	4	3	10	0	0	0	0	4	3
95 and >	0	0	0	0	1	4	0	0	1	1	3	13	0	0	3	11	0	0	6	5
Total	13		17		24		44		98		23		29		27		54		133	
Percentage below 50th percentile		69		77		80		67		72		38		27		29		66		47

Boys under two years of age had 64% below the 10th percentile and 78% below the 50th percentile for weight. However, by two to four years only 36% of boys were below the 10th percentile. Additional growth progress occurs with age as the proportion of boys with weight below the 10th percentile diminishes. This may represent catch-up growth by a shift to slightly higher percentiles, but the percent below the 50th percentile does not decline. Girls on the other hand, show an increase in the percent below the 10th percentile between birth to two years and two to four years although this is followed by a decline in the number below the 10th percentile with advancing age.

Head Circumference

The head circumference of 25 infants below three years of age was obtained and classified according to the percentile in which they fell for similar aged children on the Boston growth standards. Sixty-eight percent fell below the 10th percentile and 80% were below the median. No long-term study exists that would indicate whether the Navajo infants have small heads because of genetic or environmental (nutritional) factors, and long term measurements are needed to determine if there is a direct relationship between nutrition, head circumference and brain growth.

Hand-Wrist Radiographs

A total of 311 standardized hand-wrist radiographs of 159 boys and 152 girls aged six months to 18 years were studied to determine skeletal maturation and bone mineralization (11). The skeletal maturation of Navajo children when compared to the U.S. (Ohio) white standards indicated a delay ranging from 14% in boys to 30% in girls, equivalent to a delay of one and one-half to two years. However, size reduction was greater in males (1.4 years) than in females (0.5 years). About 20% of the Navajo children had a significant reduction in bone mineral expressed as a percentage of cortical area when compared with the U.S. standards. Studies of ossification timing and micrometric measurements of the second metacarpel suggested a retarded bone mineralization among Navajo children compared with the U.S. standards.

Interrelationship of Measures of Nutrition

Study subjects were grouped into those with "acceptable" levels of various nutritional measures and those with levels "below acceptable." Subjects also were divided into two groups with respect to height, weight and head circumference. In order to get adequate numbers in each group, subjects below age 17 years were classed as those below or above the tenth percentile in height and weight by Iowa-Boston standards or the third percentile in head circumference. Older subjects were classed into those below and above median heights and weights of the

1960-1962 National Health Examination standards. The matrix of interrelations included hemoglobin, hematocrit, ascorbic acid, vitamin A, protein, iron, transferrin saturation, total iron binding capacity, height, weight, and head circumference (under age three years).

Each interrelationship was analyzed as a 2×2 table containing above and below acceptable values for the two measures. A chi square test was made for each. Analyses were made separately by sex, seven age groups (less than 2 years, 2-5 years, 6-12 years, 13-17 years, 18-44 years, 45-64 years, 65 years and older), and various combinations of these (all male, all female, male and female combined for each age group, and grand total).

Hemoglobin, hematocrit, iron and transferrin saturation not surprisingly were interrelated at high levels. In subjects below age 18 years, height, weight and head circumference were strongly interrelated. Serum protein levels were associated with vitamin C and hemoglobin levels but hemoglobin and vitamin C were not significantly related. Vitamin A levels, TIBC, and adult height and weight were not related to any other nutritional measures.

Interrelationship of Questionnaire Answers and Nutritional Measures

Subjects were grouped according to questionnaire answers suggesting satisfactory and unsatisfactory living conditions and food practices. The interrelationship between these and measures of nutritional status was determined. Nutritional measures included hematocrit, hemoglobin, ascorbic acid, vitamin A, protein, iron, transferrin saturation, total iron binding capacity, height, weight, and head circumference (under age three years). Living condition characteristics included presence of refrigeration, way in which meat was stored, presence of water within the house, presence of toilet within the house and rooms per capita. Subjects and families also were characterized according to education, work status (unemployed, employed, full-time, part-time), and per capita weekly food expenditure.

Each interrelationship was examined in a 2×2 table with "favorable" and "unfavorable" questionnaire answers cross associated with above and below acceptable values for measures of nutrition. Chi square tests of these associations were performed.

There were few consistent, strong interrelationships. In males below age 18 years, low levels of body weight were associated with history of one or more episodes of diarrhea in the preceding month, storage of meat outside, absence of inside toilet, and less than 0.2 rooms per household member. In female children only the relationship of low levels of body weight and of rooms per capita was observed--and this association was statistically significant only for ages 6-12 years.

There were a number of statistically significant interrelationships in a direction opposite to that postulated; e.g., male children from homes

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with water inside the house had a higher proportion below the tenth percentile for weight than did those coming from homes whose water supply was outside; children coming from homes with higher per capita weekly food expenditures had more children below the tenth percentile for weight than did those coming from homes with lower per capita weekly food expenditures.

SUMMARY

Though the Greasewood survey is not directly comparable in several ways to that of Darby and his colleagues, some of the clinical and laboratory observations were similar and may provide evidence of a trend in the Navajo nutritional status during the last 15 years.

Except for thyroid enlargement, clinical signs of specific nutritional deficiency were found less frequently in the Greasewood study. Despite the high prevalence of skin, tongue, lip and gum lesions, as well as dental caries, edentulousness, circumcorneal injection, and epiphyseal enlargement of the wrists in the Darby study, they rarely found clinical signs of severe malnutrition. Even fewer clinical signs were found in the Greasewood study. Greasewood residents showed higher serum vitamin C and A levels than those of the study conducted 15 years ago.

Frank, specific malnutritional states were not often found in the younger portion of the population by clinical or laboratory examination. However, low serum levels of specific nutrients were observed in portions of the adult population, though clinical signs of specific nutritional deficiencies were not found. Marginal iron deficiency was demonstrated in all age groups by the high prevalence of low serum iron and low transferrin saturation values. Several older adults also showed low levels of vitamin C and total protein.

It was not common to find low values in the same subjects for several different kinds of nutritional measures, e.g., those with low hematocrits and serum iron levels were not necessarily more often small in size or exhibiting low levels of vitamins.

Questionnaire characterizations of living standards and food practices did not show consistent and strong relationships between standards and practices which would be considered undesirable and measures of nutritional deficiency. For example, members of families reporting the lowest weekly per capita food expenditure were not significantly smaller in size or with nutritional measures below the National Nutrition Survey acceptable level than were members of families with higher food expenditures. Possibly this indicated the invalidity of questionnaire answers or the fact that relationships were not demonstrated because of the relatively homogeneous nature of the population.

Adult men, though approximately the same height as other U.S. men, weighed less. Adult women in the childbearing years weighed more and were shorter than other U.S. women, but over age 45 years they were shorter and lighter than the U.S. standard.

The slower rate of growth and development seen in the Navajos compared with middle-class whites may be caused partly or wholly by differences in nutrition. Growth rate may be the critical criterion of borderline malnutrition. The diet evaluations suggest that many of the study subjects had inadequate food intakes which could account for growth retardation. Clinical and laboratory indices suggest that the Navajos have better nutrition now than they did 15 years ago.

Based on the data from this study further improvement in the nutrition of the Greasewood population is recommended. All age groups might benefit from increased dietary iron; children and old persons from increased total calories; and adults from increased protein and ascorbic acid. Nutritional surveys of the Navajos should be repeated in the future to evaluate the success of any supplementation program.

The excellent cooperation of the families in this limited survey of Navajo families on an Arizona reservation indicated that the careful plans to use local personnel and provide transportation for all families to the clinic appear to be necessary factors for field studies on an Indian reservation.

NOTE: Dr. Reisenger is now with the Indian Health Service at Ft. Defiance, Arizona. Dr. Rogers is Chairman, Department of Community Medicine, University of Pittsburgh. Currently, Dr. Johnson is Director, Division of Nutrition, Bureau of Foods, Food and Drug Administration, Washington, D.C.

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NUTRITION SURVEY OF WHITE MOUNTAIN APACHE PRESCHOOL CHILDREN

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In the early fall of 1968, we anticipated that our field team would be in the southwestern U.S. in the spring of 1969, involved in studies with preschool children in our national sample (1). Other studies with selected population groups (2-5) had been completed earlier and we wished to acquire additional current information on some segment of the North American Indian preschool population. During the first three weeks of April 1969 we evaluated the nutritional status of children between one and six years old who were members of the White Mountain Apache Tribe in Arizona and who lived on the Fort Apache Reservation (Fig. 1). A general review of procedures, clinical findings, analysis of growth data including skeletal maturation, nutrient intakes and clinical biochemical data follows. More information on food habits and dietary intakes is currently being summarized. Similarly, analysis of dental findings will be completed later.

PROCEDURES AND METHODS

Sample

Based on information from the Indian Health Service (IHS), Health Services and Mental Health Administration (HSMHA), Department of

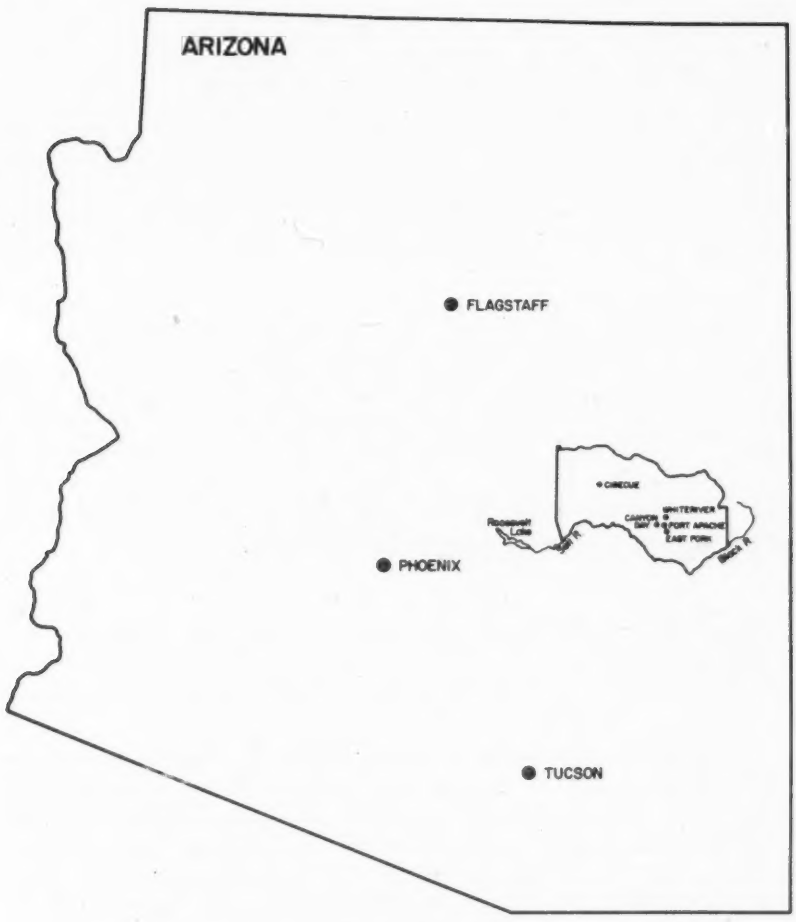

Figure 1. Map of Arizona showing location of Fort Apache Reservation.

Health, Education and Welfare (DHEW), a sample of some 200 children representing approximately 15% of the preschool children on the reservation was selected for study depending on logistics and the availability of funds, personnel and time. It was known that nearly all 5-year-old children on the reservation were enrolled in a Head Start program, so they were listed according to general area of residence (Cibecue, East Fork or Whiteriver) on the Reservation. Within these three areas, the average family size (based on numbers of children in family) was approximately equal. Accordingly, names of Head Start children were randomly selected from the list with chances for inclusion being proportionate to the contribution of each area to the total list of Head Start children. Half of the children so selected were to be included in the study if there were other children between one and six years old in a

selectee's family, one or two were designated by the dietary interviewer for inclusion in the study. Initially it was agreed that we should study no more than two children per family, but as the study progressed three children were studied in some families. The other half of the children selected from the list were not included in the study nor were any of their siblings; rather, their dwelling unit was identified and the interviewers selected the nearest dwelling unit with preschool children. This was done in order to allow inclusion of preschool youngsters from those families which did not have a child enrolled in Head Start. A more sophisticated sampling scheme could have been devised but could not have been tested and applied in the time available.

Interviews

Home dietary interviews were conducted by five nutritionists from the IHS Headquarters and area offices (6). Forms and procedures being used in home interviews in our national project were modified to fit the needs of the interviewers and local customs. Each interviewer was accompanied by an Apache woman who could speak both Apache and English. Two interviewers and a supervisor employed full-time in our program worked with the team of Indian Health Service nutritionists to code diet records.

Medical Examinations

The children and families were transported to clinic sites for physical examination. Two nurses employed full-time in our survey program reviewed children's medical histories with the assistance of bilingual Apache women. The nurses weighed the children to the nearest 25 gm, using a standard double beam set of scales which was calibrated each day with known weights. Heights were measured to the nearest centimeter with children standing shoeless with their back against a vertical surface and a right-angle level brought to the crown of the head. Frontal-occipital circumference of the head was measured to the nearest centimeter with a steel tape. Thoracic fatfold measurements were made at the left costal margin at the anterior axillary line with Harpenden calipers: successive measurements which agreed within one millimeter were accepted. With bilingual Apache women assisting, three pediatricians and a dentist from Columbus (The Ohio State University) and one pediatrician from Denver (University of Colorado) examined the children.

Laboratory Evaluation

Determinations of levels of hemoglobin and hematocrits and qualitative tests for urine glucose and protein were completed by our laboratory technician working in field clinics. Blood plasma, erythrocytes and urine specimens were promptly frozen for shipment to Colum-

bus where the remainder of the laboratory determinations were completed (plasma iron, iron binding capacity, vitamin A, ascorbic acid, total protein, albumin, cholesterol and urea nitrogen; urinary creatinine, iodine, thiamine and riboflavin). With the exception of vitamin A determinations, laboratory procedures and other methods have been described in an earlier publication (4). A fluorometric method (7) was used for determinations of plasma vitamin A level.

RESULTS

Sample

A total of 201 preschool children from 125 families comprised the entire sample. No families with eligible preschool children were known to have declined to take part in the study although participation was entirely on a volunteer basis.

Although 201 children were interviewed at home, only 164 youngsters from 97 families were examined in clinics. Half the children were nearly equally distributed in the age intervals of 12-23, 24-35 and 48-59 months. The other children were equally divided in two other age intervals, i.e., 36-47 and 60-71 months. The remainder of this report will deal with the information pertaining to the 164 children (88 boys and 76 girls) who were seen in the clinics. Of these 164 children, 74 lived in Cibecue, 48 lived in Whiteriver, 21 in East Fork, 12 in Seven-Mile Settlement and 9 in Canyon Day. Average elevation was 5,000 feet above sea level.

Interviews

Limited socioeconomic information was obtained on families included in the study. The principal occupations of the families were forestry, farming (livestock grazing) and tourism. The average parent had completed the ninth grade, was 30 years old and had between one and 13 liveborn children, with an average of six. About one-half of the fathers (or mothers in families where there were no fathers) were stated to be employed, with about equal numbers listed as skilled craftsmen, semi-skilled workers or laborers; the remainder were unemployed. Almost all the families lived in one-family dwelling units, two-thirds of which were rated poor or very poor (8). Families were relatively large; three-fourths included six or more persons, with the majority living in dwelling units with four or fewer small rooms. Only one-third had indoor toilets. Eighty-five percent of the families used community piped water, 11% obtained water from spring, stream or lake and the remainder from wells, cisterns or unknown sources. Only three families had telephones. Some 40% either owned or had use of an automobile or a truck for personal transportation. An equivalent proportion had an icebox or refrigerator and a television. More than half had radios and most had a stove (electric, gas, oil or solid fuel).

TABLE 1A

Percentage Distribution of Daily Intakes of Nutrients

Calories (Kcal/kg)	Less than 40	40–49	50–59	60–69	70–79	80–89	90–99	100–109	110–119	120 and above	N	Mean
12–23 mos.	0	14	0	23	14	18	9	4	14	4	22	85
24–59 mos.	3	11	10	17	19	13	15	4	4	4	95	76
60–71 mos.	8	0	13	23	25	10	8	4	0	5	39	73

Protein (gm/kg)	Less than 1.0	1.0–1.4	1.5–1.9	2.0–2.4	2.5–2.9	3.0–3.4	3.5–3.9	4.0–4.4	4.5–4.9	5.0 and above	N	Mean
12–23 mos.	9	5	9	18	18	9	23	0	5	5	22	2.8
24–59 mos.	1	8	15	21	25	15	9	2	3	0	95	2.5
60–71 mos.	3	3	18	26	23	13	8	3	3	3	39	2.6

Calcium (mg)	Less than 100	100–199	200–299	300–399	400–499	500–599	600–699	700–799	800–899	900 and above	N	Mean
12–23 mos.	4	9	13	4	4	13	22	9	4	17	23	609
24–59 mos.	4	22	14	14	17	6	7	6	2	7	98	412
60–71	5	14	9	9	7	21	12	12	7	4	43	495

Vitamin A (I.U./kg)	Less than 50	50–99	100–149	150–199	200–249	250–299	300–349	350–399	400–449	450 and above	N	Mean
12–23 mos	9	9	23	18	9	9	5	5	0	14	22	182
24–59 mos	31	28	15	10	11	3	0	0	0	4	95	125
60–71 mos	23	28	18	13	10	8	3	0	0	0	39	122

Ascorbic Acid (mg)	Less than 15	15–29	30–44	45–59	60–74	75–89	90–104	105–119	120–134	135 and above	N	Mean
12–23 mos	43	22	9	4	9	9	0	0	0	4	23	33
24–59 mos	41	15	15	10	7	2	3	1	2	3	98	40
60–71 mos	26	21	14	9	9	14	0	2	0	5	43	48

Iron (mg)	Less than 2	2–3	4–5	6–7	8–9	10–11	12–13	14–15	16–18	19 and above	N	Mean
12–23 mos	4	35	38	12	12	0	0	0	0	0	26	4.73
24–59 mos	4	7	33	29	14	7	2	2	1	0	121	6.71
60–71 mos	0	8	10	33	23	17	4	4	2	0	52	8.52

Riboflavin (mg/1000 Kcal)	Less than .20	.20–.49	.50–.79	.80–1.09	1.10–1.39	1.40–1.69	1.70–1.99	2.00–2.29	2.30–2.59	2.60 and above	N	Mean
12–23 mos	4	19	8	27	23	4	12	4	0	0	26	1.01
24–59 mos	1	30	31	19	9	6	2	1	1	0	121	0.77
60–71 mos	0	21	21	23	23	4	6	0	0	2	52	0.94

TABLE 1B

Percentage Distribution of Daily Intakes of Nutrients

Thiamin (mg/1000 Kcal)	Less than .10	.10–.19	.20–.29	.30–.39	.40–.49	.50–.59	.60–.69	.70–.79	.80–.89	.90–.99	1.00 and above	N	Mean
12–23 mos	0	8	15	35	8	19	0	0	12	0	4	26	0.44
24–59 mos	2	6	8	17	20	9	15	6	8	5	5	121	0.56
60–71 mos	0	2	6	6	10	19	12	15	10	6	15	52	0.72

TABLE 2

Mean Daily Intakes of Calories and of Nutrients
Apache Children 12–71 months old

	Calories (Kcal/kg)	Protein (gm/kg)	Calcium (mg)	Vit. A (I.U./kg)	Vit. C (mg)	Vit. B_1 (mg/1000 Kcal)	Vit. B_2 (mg/1000 Kcal)	Iron (mg)
Mean	77	2.6	440	132	41	0.6	0.8	7
% low	41	3	41	16	36	3	10	63
Low Intakes	<75* <60	<1.2	<250	<35	<15	<0.3	<0.4	<8

* <75 for children 12–23 months: <60 for children 24 months and older.

It was reported that only four children were receiving vitamin supplements at the time of study. Therefore, frequency distributions of intakes (Table 1) reflect essentially dietary sources of various nutrients. In general, as the children grew older, they appeared to consume progressively better diets, i.e., more adequate levels of calories and of essential nutrients. In Table 2, average intakes of calories and of several nutrients are summarized and the percentage of youngsters considered to have low intakes is also given. A significant proportion of Fort Apache preschool children were receiving insufficient calories, calcium, ascorbic acid, vitamin A, riboflavin and iron to meet requirements.

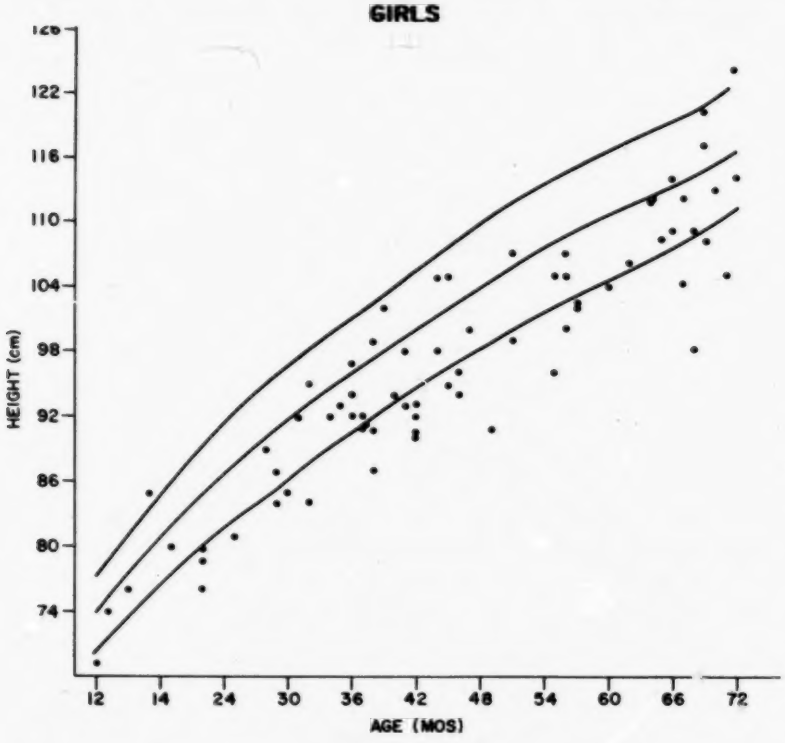

Figure 2. Heights and weights of girls compared with 10th, 50th, and 90th percentiles from Stuart's data (9).

Medical Examinations

Of 584 liveborn children in the 97 families interviewed in the clinic, 88 (15%) had died: 61 died during the first year of life, and altogether 69 died during the first five years of life. Therefore, at the time our survey was in progress, each family had an average of five living children. Eighty-five percent of children in the study population were born in Whiteriver Indian Hospital: mean birth weight of boys was 3.22 kg and

that of girls was 3.02 kg. Ten percent of the study children delivered in the hospital weighed less than 2,500 gm at birth.

A majority of the children had been hospitalized at least once. Forty-five children between 12 and 35 months of age had 114 hospitalizations or an average of two and one-half per child. Older children between 36 and 71 months of age had 234 hospitalizations, or an average of two for each child. Approximately one-third of the hospitalizations were for a primary diagnosis of pneumonia; one-third were primarily for gastroenteritis and the remainder for a variety of other reasons, frequently multiple.

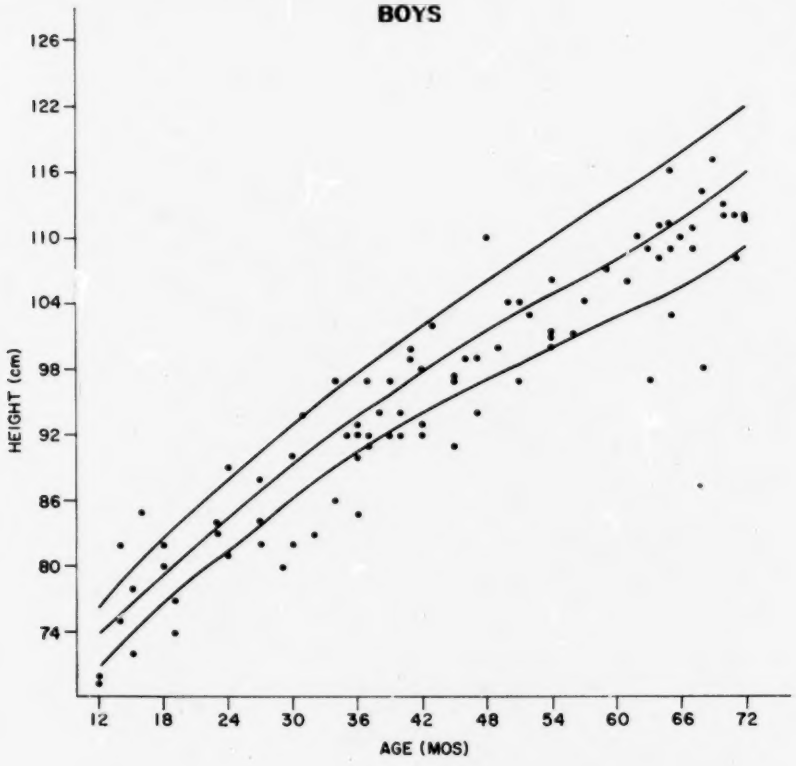

Figure 3. Heights and weights of boys compared with 10th, 50th, and 90th percentiles from Stuart's data (9).

Approximately one-fourth of the children had experienced measles and a similar proportion reportedly had experienced varicella. Three-fourths or more of the children we examined had been successfully vaccinated for smallpox and had received immunizations for diphtheria, tetanus and pertussis. Virtually all those children presumed susceptible to rubella had received measles vaccine.

Virtually all the children examined had significant dental disease, but only half were examined by the pedodontist. Analysis of data pertaining to those children will be completed later.

One-third of the children were believed to have normal physical examinations if dental findings were excluded. Other than growth underachievement, clinical findings which might be considered indicative of nutritional disorders were bowed legs--2, obesity--6, hepatomegaly--1, hair dyspigmentation--1, and pallor--2. Several children showed evidence of recent acute respiratory infections and 6 had otitis media. Several

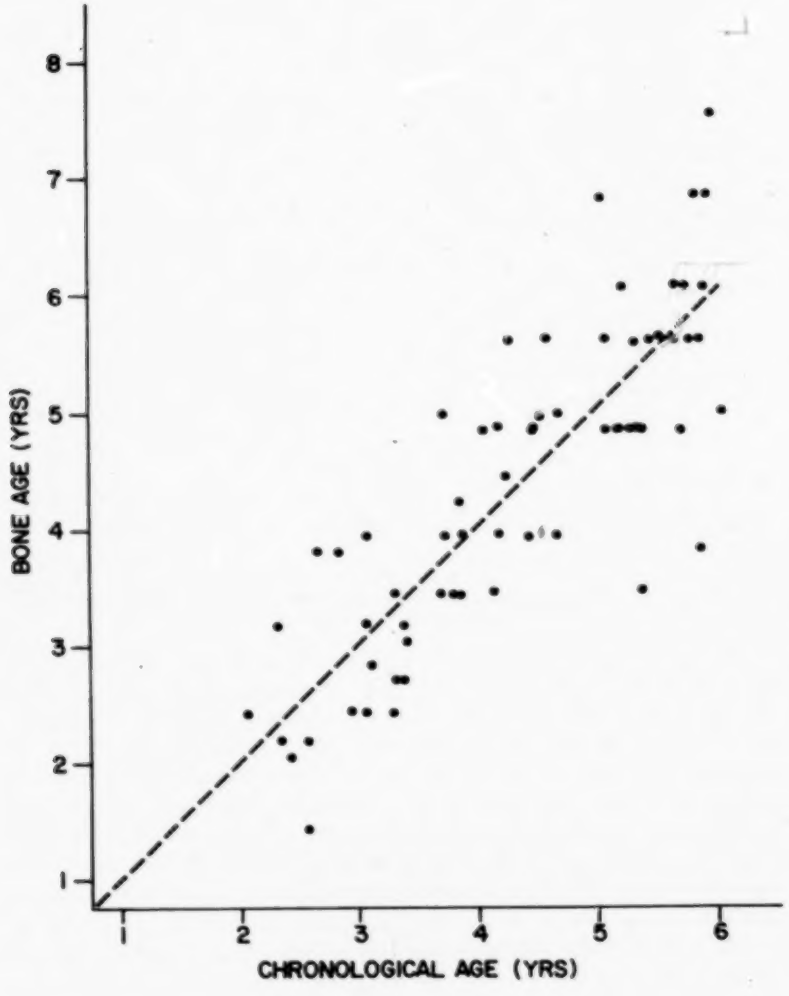

Figure 4. Bone age versus chronological age.

children had impetigo, one had a questionable atrial septal defect and another had an anal fistula.

Heights and weights of the children are shown in Figures 2 and 3. Some 38% of height measurements were below the 10th percentile of the reference chart while three percent were above the 90th percentile. Of weight measurements, 18% were below the 10th percentile and seven percent were above the 90th percentile of the reference chart. Bone ages (10) of 65 children between 24 and 71 months old are compared with chronological ages in Figure 4. Measurements of frontal-occipital head circumference (FOC) and thoracic fatfold thickness are shown in Table 3.

TABLE 3

Average Values for Head Circumference (FOC) and Thoracic Fatfold Thicknesses (FAT) for White Mountain Apache Children*

Age (mos.)	Children (no.)	FOC (cm.)	FAT (mm.)
12–17	10	45.5	5.9
18–23	9	47.1	6.1
24–29	11	47.5	5.3
30–35	14	48.6	5.2
36–41	27	48.4	4.8
42–47	21	48.4	5.2
48–53	9	49.1	4.6
54–59	14	49.4	4.7
60–65	14	51.4	3.9
66–71	25	50.2	4.9

*All measurements were made by two nurses and the values averaged for both sexes.

Laboratory Evaluations

Frequency distributions of certain biochemical determinations are shown in Table 4, and average values of these and other determinations are summarized in Table 5, where estimates of the proportions of abnormal values are also given. Plasma iron values (Table 4) paralleled the hemoglobin concentrations with rather low values observed in early life and very few low values noted during the fifth year of life. With increasing age, fewer children had low levels of vitamin A and vitamin C in plasma, which reflected a decreasing proportion of the population with low intakes of these vitamins. Four children taking multi-vitamin supplements had levels of vitamin C in plasma exceeding 1.4 mg/100 ml. Only one of the vitamin-supplemented children had a urine specimen available for examination, and thiamine and riboflavin levels were well above median values of unsupplemented children.

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TABLE 4

Percentage Distribution of Biochemical Values

Hemoglobin (gm/100 ml)	Less than 10	10.0–10.4	10.5–10.9	11.0–11.4	11.5–11.9	12.0–12.4	12.5–12.9	13.0–13.4	13.5–13.9	14.0– and above	N	Mean
12–23 mos	24	19	10	10	5	10	14	9	0	0	21	10.8
24–59 mos	6	2	7	1	1	17	13	23	13	15	82	12.6
60–71 mos	0	0	0	0	0	6	18	16	25	34	32	13.7

Plasma Iron (ug/100 ml)	Less than 20	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90–99	100 and above	N	Mean
12–23 mos	23	41	5	9	5	5	0	0	0	15	22	37
24–59 mos	10	11	6	9	17	11	9	11	5	12	94	63
60–71 mos	0	5	0	7	12	19	14	19	7	17	42	79

Vitamin A (ug/100 ml)	Less than 10	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	90 and above	N	Mean
12–23 mos	0	10	50	20	10	10	0	0	0	0	10	33
24–59 mos	2	17	40	17	12	8	3	0	0	1	65	32
60–71	0	10	16	19	26	19	10	3	0	0	31	41

Ascorbic Acid (mg/100 ml)	Less than 0.1	0.1–0.2	0.3–0.4	0.5–0.6	0.7–0.8	0.9–1.0	1.1–1.2	1.3–1.4	1.5–1.6	1.7 and above	N	Mean
12–23 mos	9	30	4	13	17	4	13	9	0	0	23	0.6
24–59 mos	6	13	9	17	19	17	10	8	0	2	90	0.8
60–71 mos	2	5	2	10	14	19	24	10	12	2	42	1.0

Albumin (gm/100 ml)	Less than 2.5	2.5–2.9	3.0–3.4	3.5–3.9	4.0–4.4	4.5–4.9	5.0 and above	N	Mean
12–23 mos	0	0	0	71	29	0	0	21	3.9
24–59 mos	1	0	2	30	59	8	0	88	4.0
60–71 mos	0	0	0	43	48	7	2	42	4.0

Thiamin (ug/gm Cr)	1 thru 249	250 thru 499	500 thru 749	750 thru 999	1000 thru 1249	1250 thru 1499	1500 thru 1749	1750 thru 1999	2000 thru 2499	2500 and above	N	Mean
12–23 mos	0	0	0	0	33	0	0	0	33	33	3	4550
24–59 mos	0	1	12	5	7	7	8	3	11	45	73	2645
60–71 mos	0	0	6	18	15	12	3	15	3	29	34	2192

Riboflavin (ug/gm Cr)	1 thru 249	250 thru 499	500 thru 749	750 thru 999	1000 thru 1499	1500 thru 1999	2000 thru 2499	2500 thru 2999	3000 thru 3499	3500 and above	N	Mean
12–23 mos	0	0	0	0	33	0	0	0	0	67	3	5750
24–59 mos	1	4	18	11	18	7	11	10	3	15	71	1975
60–71 mos	0	3	12	15	9	12	15	9	6	18	33	1173

Iodine (ug/g Cr)	1 thru 49	50 thru 99	100 thru 199	200 thru 299	300 thru 399	400 thru 499	500 thru 599	600 thru 699	700 thru 799	800 and above	N	Mean
12–23 mos	0	0	0	0	0	0	0	0	0	100	3	3925
24–59 mos	0	0	4	9	3	13	9	7	4	47	68	1413
60–71 mos	0	0	3	0	15	9	6	0	6	61	33	1173

TABLE 5

Average Biochemical Values

	BLOOD	PLASMAS				URINE		
	Hgb (gm/100 ml)	Fe (ug/100 ml)	Albumin (gm/100 ml)	Vit. A (ug/100 ml)	Vit. C (mg/100 ml)	Vit. B_1	Vit. B_2	Iodine
						(ug/gm creatinine)		
Mean	12.7	64	4.0	33	0.8	1575*	1375*	725*
% low	17	26	3	16	19	0	5	0
Low Values	<11	<40	<3.5	<20	<0.3	<175	<500	<100

*Median Values

COMMENT

It was evident to us that the Health Committee of the Tribal Council, with whom we met in planning stages of the study, accurately reflected the interest of the community at large in the desire to learn more about nutritional and health status of their preschool children. We were therefore pleased but not surprised at the high level of participation of families in the study. Some families had to travel considerable distances in order to bring children to the clinics so we were similarly pleased that 80% of children interviewed in the home were also examined clinically.

Although no attempts were made to determine income of families included in the study, the fact that 60% had received surplus commodities indicated that the majority were living in conditions of poverty or near-poverty. Housing and sanitary conditions were generally rather poor. Because distances between home and hospital were often considerable and because communication by telephone was usually not possible, it seemed likely that many families found it difficult at times to make the best use of the medical services available at Whiteriver Indian Hospital.

Statistics from birth certificates showed that in calendar years 1964, 1965, 1966 and 1967, median birth weights for Apache children (boys and girls) born in Whiteriver Indian Hospital were 3.15, 3.19, 3.07 and 3.09 kg, respectively (11). In the 117 hospital-born children (boys and girls) included in our study, median birth weight was 3.13 kg. Date of birth and birth weight of each study child who was born in the hospital were verified and the overall incidence of low birth weight (less than 2,500 gm) was eight percent, similar to the U.S. It should be remembered that on the average, these were fifth-born children in relatively large families and birth weights of those who were first- or second-born or ninth- or tenth-born were less than those of children who were fifth- or sixth-born.

There was an excess of children who were short for age at time of our study with 38% below the tenth percentile of the reference chart (9). In the Mississippi study (4), 24% of 503 children had heights below the 10th percentile. We have completed preliminary analysis of height and weight data on 1,136 children in our national survey (1) and find 20% of heights are below the 10th percentile of the reference chart. Excluding those children who had birth weights below 2,500 gm (or unknown birth weight), nearly 17% of heights in the national survey were below the tenth percentile. If Apache children with low (less than 2,500 gm) or unknown birth weights are excluded from the population, then heights of 30% of these children fall below the tenth percentile of the reference chart.

To view heights and weights of Apache children from a different perspective, we have compared them with those of 159 low-income Negro children living in rural Mississippi and of 440 children examined

TABLE 6

Distributions of Height and Weight Standard Scores (S.S.) of Three Population Groups

	S.S. $\leq$37	S.S. $\geq$63
	Heights	
White Mountain Apache	20	5
Rural Mississippi Negro	10	11
U.S. National	6	12
	Weights	
White Mountain Apache	7	10
Rural Mississippi Negro	7	9
U.S. National	9	8

in the first 13 primary sample units (15% of expected total sample) of our national study. Standard scores (13) for heights and weights were derived from the combined data of the three populations. Percentages of children in each of the three populations with standard scores above 63 or below 37 are given in Table 6.

It is evident that Apache children we studied were appreciably shorter than Negroes in rural Mississippi and also shorter than children we studied in other areas of U.S. Mothers of Apache children were also short: heights of 85 Apache women were measured in the clinics and the average height was 157 cm or approximately 8 cm shorter than the average U.S. woman with preschool children. Kraus (14) measured heights and weights of White Mountain Apache children in 1954: average heights of boys and of girls and average weights of girls were similar to those reported here while weights of boys studied in 1954 were considerably less than those reported here (Fig. 6).

It was of interest that although these Apache preschool children were short for age there was no significant delay in skeletal maturation (Fig. 2), a finding in contrast to that reported in other preschool children recently studied in Texas (Mexican-American), New Mexico and Arizona (Navajo) in the National Nutrition Survey (15). It is obvious that relative contributions of diet and of heredity to body build and growth patterns of Indian children cannot be defined. It is believed (14) that Apache and Navajo come from the same biologic stock so one might anticipate similarities in body build and growth patterns of those living in the southwestern U.S. Nevertheless, overall improvement in diet of these Apache children might be expected to result in relatively greater increase in body weight whereas similar changes in diets of Navajo children might result in relatively greater increase in height.

The average frontal-occipital head circumference values (boys and

girls) were slightly below average values of either boys or girls as summarized by Nellhaus (16). He could find no significant racial, national or geographic differences in head circumferences. Any additional comments concerning the values of the Apache children seem unwarranted.

Thoracic fatfold thickness of Apache children reflected their relative excess of weight-for-height when compared with other children in the U.S. (17) (Figs. 5,6). To the authors' knowledge, there are no data reported on thoracic fatfold measurements in U.S. preschool children. We elected to use this site in our project on preschool children because we

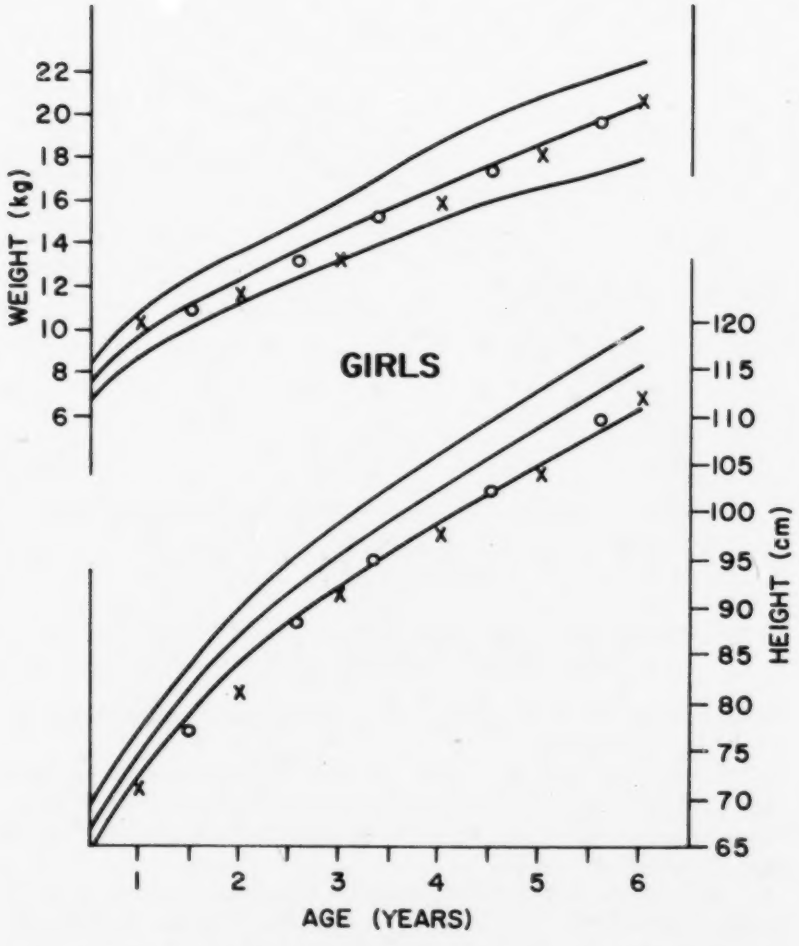

Figure 5. Average heights and weights of girls shown on Iowa Growth Chart. Values of 1954 (14) shown as x's and those of current study as o's.

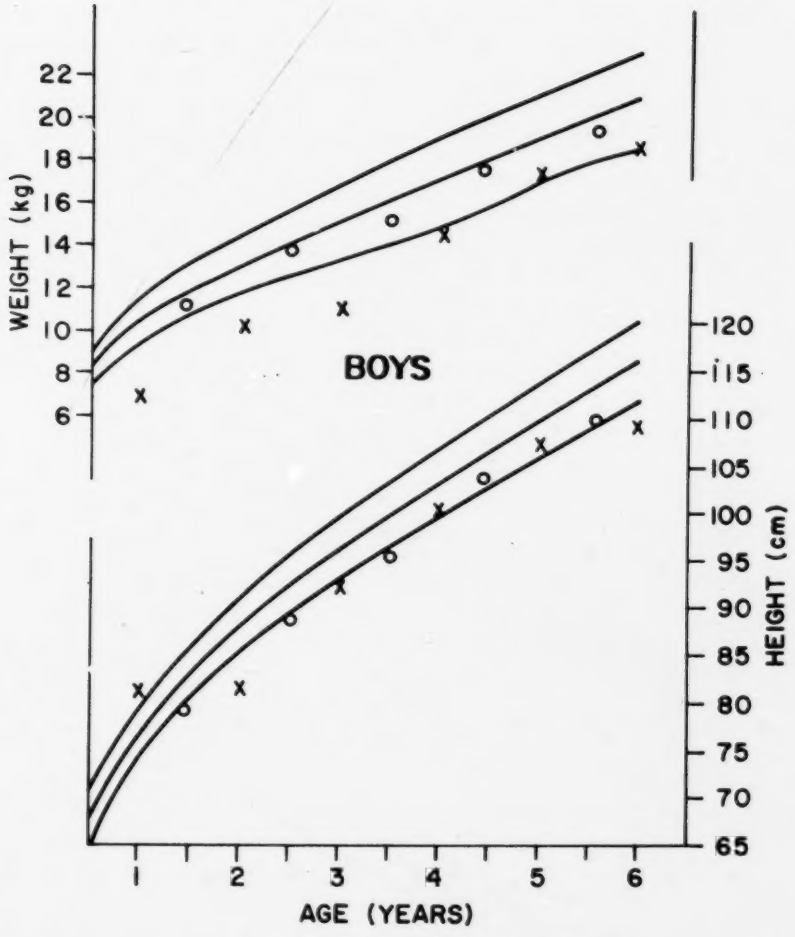

Figure 6. Average heights and weights of boys shown on Iowa Growth Chart. Values of 1954 (14) shown as *x*'s and those of current study as *o*'s.

found it to be relatively much easier to measure than triceps, subscapular or other standard sites.

Those items in limited supply for some Apache children, i.e., calories, calcium, ascorbic acid, iron, vitamin A and riboflavin were, with the exception of the latter two, those also in limited supply for some Mississippi preschool children (4).

Of 43 5-year-old children examined in the clinics, 36 were currently enrolled in the Head Start program, where they normally received during the week an estimated one-third of total food intake. During a portion of the time our survey was in progress on the reservation, school was recessed for spring vacation so only five children were actually eat-

ing at Head Start. Nevertheless, it seemed reasonable to suggest that some of the apparent age-related changes in dietary intakes (Table 1) and in biochemical indices (Table 4) may have reflected overall improvements in diets because of participation of children in the Head Start program.

It appeared that the proportion of Apache children with low levels of hemoglobin in blood or of iron, vitamin A, vitamin C in plasma or of riboflavin in urine was similar to that of low-income children in Mississippi (4) and was two or three times greater than the proportion of children in the national study (17) with low values. In our laboratory assessment, acceptable values are for the most part based on the criteria agreed upon for the National Nutrition Survey (18). A hemoglobin value of 11 gm/100 ml has been accepted as a lower limit for children beyond the age of two years, and it may be appropriate to extend that figure to children between one and two years of age (19).

CONCLUSION

Apache children, one to six years of age, living on an Indian reservation in Arizona had mean intakes of calories, calcium, vitamin A, vitamin C and vitamin B2 substantially below those that were considered sufficient to meet needs. Protein intake was quantitatively acceptable but was often of poor quality and in many instances may have been utilized to some extent to meet energy needs. The majority of Apache children were ing insufficient iron to meet current needs and to create iron store ge growth in height was significantly retarded although skeletal maturation was not delayed. About one-fifth of the Apache children demonstrated low levels of hemoglobin in blood or of iron, vitamin A, and vitamin C in plasma.

The pattern of dietary intakes, growth underachievement and biochemical evidence of nutritional risk of the Apache children was similar to that of children living in poverty in Mississippi (4). Because in both areas the population was essentially rural in character, it will be of interest to compare findings in these preschool children with those in low-income urban areas.

NOTE: This study was supported by Grant H-170 from Maternal and Child Health Services, HSMHA, DHEW. The authors gratefully acknowledge the assistance of: Physicians, H.P. Chase, R.E. Haynes, and S. Yoffe; dentist, P. Infante; supervisor, A. Johnston; preschool nutritional survey interviewers, B. Chodd and E. Dial; nurses, C. Crosby, S. Rudy, and E. Thornburgh; laboratory technician, E. Lewis; medical student, T. Thornburgh; and IHS nutritionists, D. Longman, H.G. Olson, W. Osborn, M.A. Peterson, and V.M. Wenzel.

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III

Developmental Consequences of Malnutrition

Approaches to Studies of Malnutrition
Joaquín Cravioto

Experimental Studies in Animals: Physiologic and Behavioral Correlates of Malnutrition
Richard H. Barnes

Biological Correlates of Malnutrition in Man
Stanley M. Garn

Neurological Correlates of Malnutrition in Animals and Man
Myron Winick

Behavioral Correlates of Severe Malnutrition in Man
Ernesto Pollitt

APPROACHES TO STUDIES OF MALNUTRITION

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The strategies investigators have used to study the long-term effects of malnutrition have derived mainly from their view of human malnutrition. One group considers malnutrition as an acute disorder, more or less sharply delimited in time. This attitude has led to field studies such as that of Hiernaux in Rwanda (1) and to human experiments utilizing volunteers, such as the series carried out by Keys and his colleagues (2). Another view is that of malnutrition as a chronic state, which may or may not have acute exacerbations related both to social conditions and to the age and physiologic status of the individuals at risk (3,4,5). Increasingly it is recognized that, except under highly special conditions like war or natural catastrophe, the major problem of human malnutrition is its chronicity, with only occasional exacerbations of acute diseases.

Three complimentary approaches have been developed to clarify the causal factors and consequences associated with the most prevalent variety of human undernutrition, protein-calorie malnutrition. In all three approaches the young organism is the primary focus of study, inasmuch as the consequences of even severe malnutrition in adults have been remarkably transient (6), whereas the young organism has been shown to be highly vulnerable to permanent damage (7,8,9). Given this focus, three major strategies of research have developed: 1. the deprivation model; 2. the intervention model; and 3. the natural history or ecologic model. Investigations within any of these frameworks have in-

cluded case studies, the comparison of populations and the analysis of special conditions of risk, replacement, and rehabilitation.

ANIMAL STUDIES

Animal investigations have mainly utilized the deprivation model. Animals have been used not so much to replicate the human conditions of chronic and moderate deprivation, but to examine the effects of severe malnutrition. Animals have been nutritionally deprived both qualitatively and quantitatively to determine the effects of specific nutritional deficits on growth and development. The work of Platt, Heard and Steward (10), McCance and his co-workers (11,12,13), Dobbing (14) and Barnes and his colleagues (15), among others, have provided clear evidence for at least three developmental consequences of severe malnutrition. First, animals exposed to nutritional deprivations early in life exhibited growth failures not fully repaired by subsequent rehabilitation. Second, such early severe malnutrition resulted in lags in maturation accompanied by the development of abnormal metabolic and enzymatic patterns. Third, in almost all instances in which behavior as well as central nervous system structure and composition has been carefully studied, the exposure of the animal to malnutrition has resulted in central nervous system abnormality and some degree of behavioral incompetence.

The dramatic effects of severe nutritional deprivation have led several groups to examine conditions in animals that more fully mimic the human condition. These investigators have provided animals with moderate, but persistent, degrees of nutritional deprivation and have studied the effects on subsequent generations. Chow and his co-workers (16,17) have shown that offspring of rat mothers fed sufficient calories, but protein of poor quality, were stunted at birth and remained stunted even when a full ad libitum diet was available after weaning. Cowley and Griesel (18) and Platt and his colleagues (19) have focused less on physical characteristics and more on the functional and behavioral consequences of chronic malnutrition. Cowley and Griesel produced evidence suggesting that such deprivation has cumulative effects on learning capacity. They have demonstrated that rats nutritionally deprived over successive generations manifest increasing degrees of learning deficit. Platt and his co-workers have studied pigs rather than rats to demonstrate behavioral, anatomic and neurophysiologic consequences associated with chronic malnutrition.

Animal studies based on the deprivation model have been extremely valuable, since they permit an examination of the effects of malnutrition on biologic structures utilizing controlled conditions which would be impossible and immoral to achieve in the human organism. They have provided data on specific organs, systems and mechanisms of biological organization most likely to be affected when exposed to malnutrition. Moreover, they have inspired such specific studies as those of Flexner

and his co-workers (20,21), who have used metabolic blocking agents to study the effects of the deprivation of nutritional elements on memory.

HUMAN STUDIES

Animal studies cannot provide a complete analogy to the human conditions. Experimental animals lack the social substrate against which human nutritional deprivation takes place and with which it interacts. Furthermore, the effects on behavior have necessarily been limited to the simple types of behavioral adaptation possible for the lower animal. Therefore, the effects of malnutrition on complex behavioral and social functions could not be studied and the analogy, though useful, is incomplete and complements rather than substitutes for the study of the effects of malnutrition in man. Interestingly, Winick has found that brains from children who died from protein calorie malnutrition showed a reduction in cell number roughly equivalent to that obtained in severely malnourished rats (22).

The study of malnutrition and its effects on man and his functions has taken place in many settings and derived both strengths and weaknesses from the settings and the investigative model employed. Except for studies of subacute malnutrition in adult human volunteers carried out by Keys and his associates (2), almost all studies have capitalized on malnutrition spontaneously occurring under conditions of social dislocation. These conditions may have been acute, as in the case of Antonov's study of pregnancy during the siege of Leningrad (23) and Smith's study of acute food deprivation in Holland (24); or chronic, as in the case of Dean's studies in Kampala (3). The populations studied have ranged from a series of individuals hospitalized for malnutrition to whole communities studied by epidemiologic methods (25). In assessing the effects of malnutrition on both physical and behavioral development in such settings, two general approaches have been employed: intervention and ecologic.

INTERVENTION STUDIES

The intervention approach represents the other side of the deprivation coin. Through it the investigator seeks to assess the conjoined effects of nutrition, infection, and familial and social circumstances by systematically altering each of the relevant variables. In practice this has meant the differential application of food supplementation, infectious disease control, improved housing, education, economic support, and increased opportunities for social learning in presumably equated communities or population samples. The appeal of this method is that it attempts to separate influential variables and compares them in a manner similar to that used in the standard laboratory experiment. Unfortunately, it is extremely difficult to achieve comparability of groups and to prevent spread of effect when subsections of a single population are differentially manipulated. The use of different communities

minimizes possibilities of spread but increases the problems of comparability. In either situation, each time a single variable is affected, the danger of ecologic rearrangement exists, particularly when the primary variable that is manipulated is food, which impinges on many aspects of the economy and home life.

Moral problems also arise in the use of food supplementation in studies based on the intervention model. Perhaps the principle problem is the recognition that such supplementation will in most instances be terminated at the end of the study period. The effect of the supplementations on food ecology with the potentially disastrous consequences of termination cannot be viewed lightly. Clearly, however, such a consideration is moral rather than methodological; properly anticipated, the transition can be planned and facilitated in a constructive manner.

The major methodologic problem with nutrition supplementation is the comparability of the groups. To insure comparability, particularly when a complex phenomenon is under study, a detailed ecologic analysis of the groups to be used is necessary. Such an analysis in itself may provide a basis for preliminary identification of determinative variables. The Guatemala study clearly illustrates the complexity of the intervention approach.

ECOLOGIC STUDIES

The ecologic approach is a particular form of the natural history method. It seeks to determine the nature of effective variables through consideration of their interrelations in a single population. When applied to the problem of malnutrition it attempts to tease out patterns of cause and consequences by considering the interrelations among food, health and social factors over time.

Using the ecologic approach over an extended period, as in the Mexico study, it is possible to identify age-specific conditions of risk, relate antecedents to consequences at different developmental stages, and integrate biologic and social time scales. Researchers using this approach can consider both the macro- and the micro-environment of the developing individual and deal with the interaction of biologic and social variables. Perhaps most important for its usefulness is recognition of uncontrolled variation as the factor under study. Therefore, a basic requirement for the use of the ecologic method is sufficient variation in the factor to be considered in the population studied. If such variation is present, associative analysis can serve to identify, segregate and interrelate the factors influential in affecting the consequences with which one is concerned.

A major problem with the ecologic approach is the multiplicity of factors to be measured coupled with the quantification of many of the social and familial factors. Very complex and sophisticated analytic approaches are essential. A moral issue also may be encountered in longitudinal studies if systematic efforts are not made to improve the en-

vironment, particularly in regard to nutrition and health, since random improvements in care may result in irreversible changes in the individual's internal or external environment. However, like the intervention approach, ecologic studies can contribute significantly to our knowlege of human development and can be terminated to the benefit of the populations under study.

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EXPERIMENTAL STUDIES IN ANIMALS: PHYSIOLOGIC AND BEHAVIORAL CORRELATES OF MALNUTRITION

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The effects of nutritional deficiencies during early life on behavioral development in experimental animals is a fascinating and productive line of investigation. The mere fact that long-lasting behavioral changes occur in an animal solely by manipulating its diet for a short period of early postnatal life suggests many possibilities of exploring nutritional, biochemical, and drug interrelationships with behavior (1). On the other hand, the hypothesis that malnutrition in the infant causes retardation in mental development, usually interpreted as "intelligence," has been discussed, reviewed, editorialized, and frequently accepted as fact by scientists and politicians, as well as by a large segment of the public. To my knowledge, however, no direct evidence has been obtained from observations in the human that permits this conclusion. Furthermore, because of the complex interrelations between economic, sociocultural, and nutritional characteristics within population groups where severe protein-calorie malnutrition is endemic, the possibility exists that investigations may never establish a causal relation between malnutrition and intelligence or capacity to learn in man. Even considering the more optimistic, and probably more realistic, end result of the vast worldwide research effort currently being conducted with human populations which could provide proof of this causal relationship, animal studies will continue to play a key role in devising

and testing protective or curative types of intervention, and possibly even pinpoint the critical period when damaging effects of malnutrition are most prominent.

Below I will describe some of the nutritional and behavioral factors that have been examined in our laboratories. The results will help demonstrate the use of experimental animals in studying both practical and theoretical problems regarding malnutrition. When we work with animals we wonder whether to interpret the results in terms of the same mechanisms in man, and whether to recommend the initiation of action programs based on suggestive results in animals. These questions plague us continually, but nevertheless I think the experimental animal is important as a tool for understanding some of the problems of health and behavior as they may exist in man because of two specific advantages of experimental animals. First, we can vary the nutritional situation at any time throughout an animal's development, from gestation through early infancy, growth, or old age. Obviously this cannot be done in man; here this situation must be studied as it is found. The second advantage of using experimental animals is that environmental, social, and cultural influences can be separated from the influences of malnutrition.

STUDIES WITH RATS

Below is a detailed description of a few recent experiments that represent only a part of the program carried out to date. Large numbers of pregnant female rats were bought with the understanding that they had all become pregnant on the same day and presumably would give birth to litters on the same day. Litter sizes were adjusted to eight young per lactating dam. One half of the females were fed a purified, adequate diet and the other half, or experimental group, a diet deficient in protein (12% casein, where 25% is optimal) from the first day after birth. The lactating females were fed this diet for the remainder of the suckling period of 21 days. The reduced protein intake depressed the milk production, so that the suckling young were underfed and were about one-half of the weight of the control animals when they were weaned at 21 days of age. The controls were weaned onto an optimal protein--25% casein--diet. The young rats in the experimental group that had been restricted during the suckling period were divided into two groups, both fed a purified diet complete in all nutrients, but one group was fed an optimal protein (casein) diet while the other received one low in casein (3% compared with 25%). After consuming this diet for four weeks, the experimental group fed the low protein diet was given a completely adequate, purified diet until a series of behavioral tests was completed approximately four months after nutritional rehabilitation (1).

All malnourished rats exhibited the expected, well established stunting of growth (Fig. 1). They also showed an abnormal eating

Figure 1: Rats of the same age (seven weeks). The smaller rat had a reduced milk intake during the three-week postnatal suckling period, followed by a very low protein diet (three percent casein) for the next four weeks.

behavior, evidenced by excessive spillage of food when deprived of it for 24 hours and then given food for only one hour each day. The animals also showed some bizarre metabolic changes. Those malnourished both before and after weaning ate about 15% more food and 40% more water per unit body surface area during the nutritional rehabilitation period than either the controls or the other experimental groups, but in these most severely malnourished rats, body composition showed a decreased, rather than increased, fat content (2). That is, the previously deprived animals ate more and gained less than normal rats. Enlargement of their adrenal glands was also consistently observed.

BEHAVIORAL TESTS

A variety of behavioral tests performed on all groups of the previously malnourished, rehabilitated animals clearly demonstrated their elevated levels of excitement or overreaction to stressful stimuli. In an active avoidance situation where the animals must act to avoid a painful stimulus the rats pressed a bar to avoid a shock administered at 15-second intervals. Each bar press reset the time interval to a new 15-second period. Bar pressing was more frequent with the previously malnourished animals. During a 45-minute test period, the experimental animals increased their bar pressing reactions at a greater rate than the controls. They maintained this same pattern of response rate over a number of succeeding days of repeated testing.

Free-moving mobility was measured by placing a rat in a box with the floor marked in squares. The average number of squares covered

during three 10-minute sessions showed a significantly greater mobility in the previously malnourished rats. Mobility was then measured in a different cage situation where, after a period of adaptation, the rat was subjected to a loud, sharp noise caused by the activation of a solenoid. The typical response by all animals was a freezing of movements and eventual exploration of the surroundings again. Comparison was made of the animal's mobility during the 10-minute periods immediately preceding and after the sharp noise of the solenoid. The percentage reduction in movements after the noise was considerably higher for previously malnourished rats (1).

A typical conditioned avoidance situation was also examined (3). Rats in an enclosure with an electrified grid floor were subjected to a conditioned stimulus (CS) in the form of a high frequency tone which continued for 160 seconds, or until the rat jumped to a wire mesh screen at one end of the enclosure. The weight of the animal would break a connection which discontinued the CS. If the animal had not jumped on the screen during the first 10 seconds of the CS, it received an unconditioned stimulus (US), an electric shock, and intermittent shocks were administered for the next 150 seconds or until the connection was broken by the weight of the rat on the screen. After a one-minute intertrial period, this test procedure was repeated for a total of seven successive trials per session. This entire protocol was repeated every other day for six complete sessions. Both previously malnourished and normal control rats acquired the conditioned avoidance response at the same rate. However, after the first two or three test days, the animals began to remain on the screen for increasing periods during the intertrial periods. The previously malnourished animals reacted in this manner much more often than the controls. Because the animals remained on the screen even though the CS had not been given, it was necessary to modify the test protocol to wait until the animal had returned to the floor of the box for at least 15 seconds before imposing the next CS. In view of the results previously described in which a bar-pressing avoidance had been employed, our interpretation is that this prolonged hanging on the screen, which delayed the administration of the succeeding CS, was probably another manifestation of the Sidman type of active avoidance (4).

After the six complete sessions had been conducted, an extinction-type situation was imposed in which a continuous CS was administered but no US was given. The total time each rat remained on the screen during each minute for a total of 15 minutes was recorded. The results showed a highly significant delay in the previously malnourished rat's ability to inhibit its responses in this extinction-type of situation (3).

STUDIES WITH PIGS

The pig has certain advantages over the rat in the study of malnutrition, since the baby pig can be weaned one or two days after birth,

surviving on a liquid diet without the need for artificial or manual aids. At three weeks of age the infant pig can be fed a solid purified diet, making possible the introduction of many nutritional alterations. In studies over the past five years we have shown that severe protein deficiency initiated at three weeks of age and lasting for only eight weeks caused behavioral abnormalities which were still observable about six months after complete nutritional rehabilitation, when the animals had reached a weight of 150 kg or more. Classical Pavlovian conditioning was studied extensively in these animals. In repeated experiments, previous malnutrition had no observable effect upon the rate of acquisition of conditioned responses. However, pigs malnourished early had a marked impairment in their ability to extinguish a well established conditioned response (5).

Recent studies have attempted to describe in more detail the abnormal behavior caused by early malnutrition (6). Four types of malnutrition were used in the studies described below:

1. Restricted intake of an optimal diet from three to 11 weeks of age.
2. Low protein diet (3% casein) ad libitum from three to 11 weeks of age.
3. Low protein diet (3% casein) ad libitum from seven to 15 weeks of age.
4. Restricted intake of an optimal diet from birth to eight weeks of age.

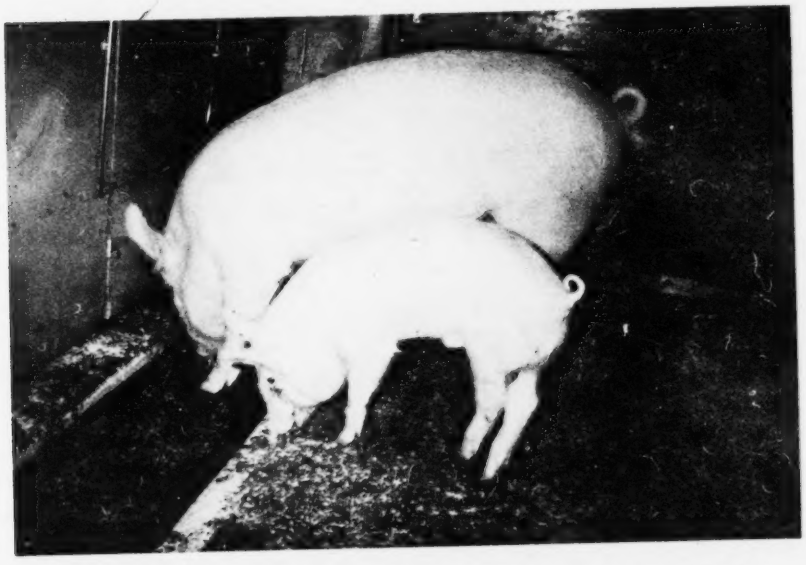

Figure 2: Pigs of the same age (15 weeks). The smaller pig had received the low protein diet (three percent casein) for the previous eight weeks and developed extensive edema, particularly noticeable around the jowls. Otherwise outward appearance was normal except for the small size.

5. Optimal diet ad libitum from birth to 15 weeks of age (control group).

In each of the experimental groups, rehabilitation was accomplished by feeding the optimal diet (a purified diet containing 18% casein) after the period of malnutrition for approximately two weeks; then all pigs were fed a commercial swine ration until behavioral testing was completed. Growth was stunted in the malnourished groups, as expected from previous studies (Fig. 2) (5). At approximately five months of age the pigs were subjected to a battery of behavioral tests; one group of those tests is described here.

BEHAVIORAL TESTS

Each pig was brought into a square room measuring approximately 2.5 meters on a side (Fig. 3). The room was divided into four equal sections by 1.5-meter-high partitions extending from the center to about a 0.5 meter from the outer walls. This arrangement left openings between

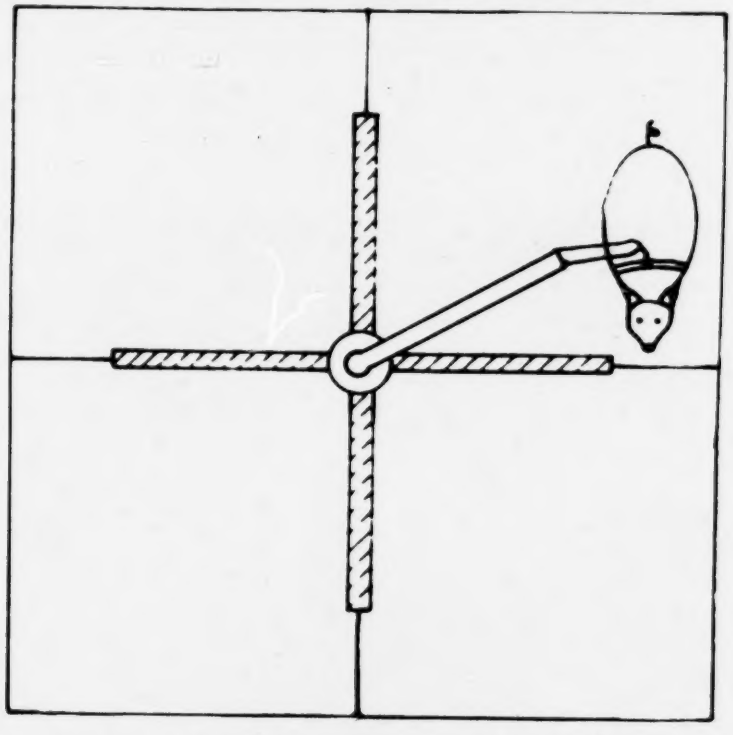

Figure 3: Diagram of the behavioral testing unit for pigs. The doorways joining the four sections contained either minimal obstacles (7.5-cm high wood braces) or 30-cm high hurdles. Overall dimensions of the room were 2.5 × 2.5 m. (*From Barnes, R.H., Moore, A.U., and Pond, W.G.: J. Nutr. 100: 149, 1970.*)

the four sections through which the pigs could walk. For certain tests, hurdles about 30 cm high could be inserted in these openings. In the center of the room was a revolving cylinder at the top of which a horizontal arm was attached. To the free moving end of the arm was fixed a harness which could be strapped around the chest of the pig. Saline-soaked contact electrodes were part of this harness for the administration of electrical shocks. Recording devices were arranged so that movements of the pig from one section to the other could be measured. All pigs were naive to the room and the harness.

In the first test, the pigs were fixed in the harness and the hurdles removed to permit free exploration of the new environment. All pigs manifested evidence of excitement during the first few minutes in this strange situation. They moved rapidly through the passages and many vocalized with squeals and grunts. The control pigs quickly calmed down and began to sniff the floor and partitions in a manner suggesting exploration. On the other hand, previously malnourished animals continued their excitatory behavior throughout the 14 minutes of observation, although pigs fed a low protein diet from three to 11 weeks overreacted more than the other experimental groups.

The second day and for three successive days the pigs were returned to the test rooms, but on these occasions they were subjected to a conditioned avoidance situation. An intermittent buzzer was the CS which was followed by a US in the form of an electric shock if they did not move from one section of the room to another within 10 seconds of the CS. Movement to another section during this 10-second period stopped the CS. Low hurdles were introduced in this phase of testing. All pigs learned the avoidance problem quickly; however, the group fed a low protein diet from three to 11 weeks learned significantly less quickly than the control group.

On the sixth day, i.e., the day following the three learning sessions, an extinction-type situation was imposed. The intermittent buzzer was set in motion, but this time no shocks were given and movement to a new section did not stop the CS. During the 10-minute session the control pigs rapidly calmed down and moved in exploratory-like activity. All experimental groups had delayed adaptation to the new test situation, but the group fed a low-protein diet from three to 11 weeks showed the least change in behavior during the test period. These animals continued to respond by running and vocalizing throughout the test, indicating an exaggerated overreaction or inability to inhibit their previously learned responses.

CONCLUSIONS

The behavioral characteristics described here certainly confuse the interpretation of the usual tests of learning performance in animals. The delayed extinction of a conditioned response in the severely malnourished animals and the impairment in acquiring a conditioned

response are both deviations of basic mechanisms for learning, particularly in the early life of the human. It could well be asked whether the results of these tests provide evidence of impairment of the mechanism of learning. However, the measurement of learning in an experimental animal always involves some form of reinforcement. The animal is rewarded for making a correct response and punished for making a wrong one.

Previously malnourished animals react differently from normal ones to the various forms of reinforcement that are commonly used. They have different attitudes toward food and water, so that if they are hungry or thirsty, they may exhibit exaggerated, possibly erratic, responses toward these rewards. It is difficult to tell whether the results obtained in a maze test, for example, result from learning or the level of motivational drive. They also react differently to frightening stimulation, and fright in the form of electric shock is commonly used in avoidance type of learning experiments.

Elevated levels of excitement or overreaction to stressful stimuli will confuse the interpretation of other forms of learning tests that utilize aversive stimuli for reinforcement. The previously malnourished animal exhibited elevated excitement when confronted with a painful or aversive stimulus such as an electric shock or submersion in cold water. Therefore, it is difficult to interpret the meaning of learning performance tests in these animals, since one does not know whether test performance was affected by a change in capacity to learn, or intelligence, or whether the attested strength of the reinforcement was responsible. Even though the previously malnourished animal shows a change in learning performance in tests such as mazes that are intended to measure ability to learn, one cannot conclude that this is evidence of impaired intelligence or capacity to learn.

Because of these confounding variables, to my knowledge no conclusive evidence exists, in experimental animals and certainly not in humans, that early severe malnutrition causes impairment in learning capacity or intelligence as such.

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BIOLOGICAL CORRELATES OF MALNUTRITION IN MAN

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Biological correlates of human malnutrition resolve themselves into two clusters of problems. The first, relating to the biological correlates of malnutrition in general, apply in principle to the Indians of North America as well as to the more thoroughly investigated Indian and Mestizo populations of both Central and South America. The second set of problems includes the population biology and cultural experiences of North American Indians, taken group by group rather than as a single geographical race. I hesitate to generalize about "Indians" as a whole. Genetically, culturally and nutritionally, it is the group rather than the larger taxonomic category that has health meaning.

It is not practical to review in detail the individual types of malnutrition. It is pertinent to observe that simple caloric malnutrition may have been the more common form in pre-contact days, even in maize-cultivating areas, since excessive dependence on a single cereal with its limiting amino acids probably did not exist for North America, even in selected areas in the Southwest. On the other hand, vitamin C deficiency apparently existed--on a seasonal basis--in the colder areas of North America. Recently several workers have suggested that the multiple, recurrent (often yearly) bands and lines in prehistoric Indian bones actually are permanent reminders of seasonal scorbutic bone lesions.

PRENATAL CORRELATES OF MALNUTRITION

Judging from studies in wartime Russia (1) and Holland (2), as well as from experimental animal studies, reproduction suffers in malnutrition. As caloric intake lessens, ovulatory cycles become fewer, spermatogenesis diminishes, and net reproductive fitness decreases. Without going into details--protein requirements, or zinc and spermatogenesis, for example--it would seem at first that malnutrition should lead to a decrease in the birth rate.

It is significant that the studies in Holland and Russia describe previously well-nourished populations where women of child-bearing age probably consumed 2,500 calories per day, had protein intakes of 50 grams per day, or more, and had no major limiting nutrients. These findings do not hold for present day India where reproduction continues below 1,800 calories per day and probably even below 1,300 calories.

I see no evidence for the thesis presented in *The Biology of Hunger* (3) that caloric deprivation is an actual spur to reproduction, merely noting that in the culture of poverty and the climate of hunger, people turn to each other. But it is obvious that adaptation to simple malnutrition exists, that people in India reproduce at levels of caloric intake that would produce anovulatory cycles in previously well-nourished women. Habituated to a lower caloric intake, with a lower lean body mass to support, with far less fat to maintain, with restricted voluntary activity, reproduction goes on. So adapted, one-third less woman (in total body weight) seems to be capable of maintaining enough conceptuses to match women in better-nourished populations, though with probably greater perinatal and certainly greater infant mortality.

Theoretically, smaller women (and smaller men) should be at a reproductive advantage in simple malnutrition, and this may have been a factor in reducing "genetic size" over time in areas of chronic caloric deficiency. On the other hand, this simplistic genetic explanation ignores the ability of groups to undergo massive secular increase in size in the presence of caloric adequacy.

It is much more likely that occasional acute episodes of malnutrition rather than chronic malnutrition states (as in the example of India) remodeled the American Indian populations by limiting reproductive capacity, lactation, and perinatal and infant survival. On the other hand, population expansion in American Indians is presumptive evidence of improved caloric adequacy.

PERINATAL ASPECTS OF MALNUTRITION

It is well known that caloric deprivation reduces prenatal growth inasmuch as the fetus is (in its way) quasi-parasitic. We know further that at some levels of caloric intake and maternal fatness, maternal dietary restrictions are not followed by a comparable decrease in birth size/weight/fatness. Preconceptional as well as prenatal levels are im-

portant--a woman with 60 pounds of fat at the third trimester may not produce a smaller infant if she is then reduced to but 55 pounds of fat. But if she has only 8 or 10 or 12 pounds of fat to begin with, the size of the newborn may be more stringently diminished.

Calories available to the mother, and the size of the mother, are both nutritional variables to consider. I am not at all sure at what point the mother still produces developmentally complete though smaller offspring, and at what point she delivers progeny that are born smaller, less developed, and therefore less able to cope with the extra-uterine environment. At some point it is probable that size restriction is associated with diminished brain size in progeny, progeny that are borderline in the Apgar tests, and therefore high-risk with potential or actual neurological problems (4).

The data on low birth-weight, but developmentally "mature" infants and their later intelligence scores are contradictory. Such infants born with small placentas ("prenatal placental malnutrition") may possibly still be retarded at four years of age. They do show catch-up growth in head size; certainly they are less retarded behaviorally than dimensionally. On the other hand, the smaller twin, which also was nutritionally deprived during pregnancy, may show intellective deficits for many years thereafter.

The extent to which prenatal malnutrition of the caloric or placental types permanently delays growth and causes intellectual retardation is an open question. The answer lies in whether fetal cells produced during maternal deprivation then continue to serve as models for postnatal cellular growth. If confirmed then it is possible that entire groups may be retarded in later life because of maternal malnutrition.

MALNUTRITION FOLLOWING WEANING

The classical example of protein-calorie malnutrition, as described by Dean (5) and others, is one of adequate or even advanced development up to the time of weaning, with a gradual drop in the rates of both somatic and psychomotor development thereafter. We now know this to be an over-simplification, presupposing as it does a) an adequate level of prenatal maternal nutrition and an adequate supply of breast milk, as well as b) an abrupt shift to a low-protein or poor-quality protein post-weaning dietary. It is complicated by infection--as many studies by the Institute of Nutrition of Central America and Panama (INCAP) have shown--and by parasites (6). However, the general principles hold and are particularly applicable to those situations where changes of acculturation and urbanization result in early weaning without the financial resources for nor the nutritional knowledge concerning adequate replacements. In such situations somatic delay can be marked: as much as a 33% delay in the second-cycle postnatal ossification centers; diminished growth in length; lesser buildup of lean tissue; diminished bone growth subperiosteally at the partial expense of the endosteal sur-

face; and outer fat reduced to the very minimum registered on the Harpenden or Lange fatfold calipers.

Early weaning from the breast to the bottle and cup has been long practiced in the United States, to the point where nursing is now either a minority group lag, or an obvious exercise in a system of beliefs. Early weaning has been practical because of the availability of safe fluid cow's milk. But bottled cow's milk, available ad libitum, has made its contribution to infant malnutrition too. Though cow's milk contains three times the calcium of breast milk (7), calcium could not be adequately incorporated into the growing bone. Low levels of vitamin D in unfortified milk has led to classic vitamin-D-deficiency rickets. There are still numerous reports of vitamin-D-deficiency rickets where unfortified milk is sold; this practice constitutes an obvious hazard where cow's milk acculturation has preceded legislative action. Furthermore, the shift to cow's milk with a high caloric density contributing to weight gain, coupled with its excessive use through the first birthday and beyond, has brought about another problem--that of iron deficiency, with its deleterious results on growth and development.

Weaning at any age has an inhibiting effect on growth and development unless the substitute diet is nutritionally complete. Weaning to a cereal gruel or a calorically-adequate but protein-deficient infant diet is a sure setting for protein-calorie malnutrition. Weaning to a bottle has its hazards if vitamin D is limited, or if iron intake is low in the presence of virtually unlimited calories. The "big baby," a source of satisfaction to grandmothers, may at the same time be a malnourished baby. In these cases we may have exchanged one kind of malnutrition for another.

NUTRITION AND INFECTION

The biological correlates of malnutrition, as seen during growth and development, demand mention of the third partner, infection. As is now well known, malnutrition in infancy is particularly morbidogenic in the presence of infection (8). Mortality from all childhood diseases (including viral respiratory diseases) is extremely high where malnutrition exists. Childhood diseases in the malnourished youngster may at the same time lead to protein loss and to protein-calorie malnutrition.

Indeed, the increasing body size and earlier maturation of people in developed countries does not just reflect an improvement in caloric intake during infancy through adolescence, nor just a decrease in calories lost. It also is a result of a reduction in infections of all sorts, from the infantile diarrheas on to the diseases now countered by immunizations. Better-nourished populations have experienced less loss of growth potential due to infection, and--with less infection--a better use of all nutrients for growth. The effect of antibiotics incorporated into the feed on feed efficiency in our domestic animals is an objective case in point.

Many of the common childhood diseases were unknown in pre-contact America. These diseases were European gifts, like smallpox and

whiskey. Pre-contact Indian children may not have been "Children of Nature," but they had fewer infectious ailments of childhood to contend with. In groups of a few hundred to a few thousand, they also had less experience with the recurrent respiratory epidemics we now regularly import from Europe and Asia, at 600 miles per hour.

Some of our European diseases still are unusually prevalent among American Indians. Immunization procedures and general medical care may still be limited. The joint problem of infection and nutrition must be repeatedly emphasized for Native American children. Their resolution is unavoidably intertwined.

MALNUTRITION AND DELAYED GROWTH THROUGH ADOLESCENCE

The first student riots at Harvard took place a full three centuries ago. The ostensible complaint then was the quality of the food, and it is clear in retrospect that the Harvard undergraduates of 1670, wealthy though they were, did indeed suffer malnutrition and so did the the rest of the world. We know now that malnutrition (including infection) limits growth, delays adolescence and decreases final size.

Adolescent growth (or more correctly the steroid-mediated phase of growth) is in part delayed by malnutrition. In part the onset of FSH-LH production waits for size to catch up. But this is only partially true. As we can show in Guatemala and El Salvador and Costa Rica, the timing of the adductor sesamoid is not nearly as delayed, percentage-wise, as the timing of the trapezium, trapezoid, navicular and distal ulna (9). This we have shown with Dr. Moises Behar and the INCAP group, and it has been seen in other developmental delays we have more recently studied.

Malnutrition during infancy and childhood reduces size prior to adolescence through multiple effects on growth attainment and developmental progress. Malnutrition delays adolescence so dramatically that it can be demonstrated in the less-fat children in well-nourished populations. But the delay of adolescence is less than might be expected from childhood delays in growth and so ultimate size attained is less.

I do not know whether nutritionally-delayed adolescence is associated with a longer adolescent "spurt," nor do I know whether gametogenesis is proportionately or disproportionately delayed in such cases. There is no evidence that the delay between menarche and the attainment of regular ovulatory cycles is longer in malnourished girls, though the gynecologists among us may possess the very facts we need. Nor do I know whether nutritionally-delayed adolescence is associated with a longer period of adult growth, though I suspect it is.

In malnutrition then, growth is delayed and adolescence is delayed, but to a lesser extent. The result is an individual sexually mature at a far smaller size, and then capable of supporting the conceptus possibly less long and to lesser sizes in turn.

EARLIER MALNUTRITION AND ADULT EFFECTS

As a result of earlier or still-continuing malnutrition, size attainment is diminished and adulthood delayed. The extent of nutritional size reduction is easily four inches and it may be six inches and possibly more, nearly three standard deviations. The extent of developmental delay, approximately 33% in extremely undernourished populations during the later preschool years, is larger than the delay in maturity, which may be nearer 15%. Malnourished individuals and groups enter into puberty small, and end it relatively smaller still. They "catch up" in timing but not in size.

These simple figures of size and maturity conceal even larger differences in the composition of the body. A nutritionally-caused reduction of 35% in the lean body mass of males is altogether possible. In continuing adult caloric malnutrition, the weight of fat is easily less than one-third of that of "average" young male adults of European origin.

It is not known how much recovery of tissue mass can be achieved once malnourished growth effectively ceases. It is possible that statural growth (growth in size) may continue until after age 30 in previously malnourished people. It is a guess as to what degree of "recovery" in muscle mass is possible after nutritional restriction during the adolescent years. But malnourished children and adolescents rarely have the opportunity to replete themselves as adults.

The effects of malnutrition are to produce a smaller woman, with less tissue mass, therefore productive of a smaller infant, and so malnutrition in one generation has its effect on the next. If bone size is attained at the expense of preformed bone in malnutrition, and unless bone can later be added at the inner (endosteal) surface, there may be a further diminished mineral mass, with more severe symptoms of bone loss (osteoporosis) in later years of life (10).

The point is that earlier or continuing malnutrition has implications well beyond childhood and adolescence. Affecting one generation, its consequences may extend to the next, and even the next.

GENETIC DIVERSITY OF THE AMERICAN INDIAN AND ITS NUTRITIONAL IMPLICATIONS

We refer to "North American Indian children" in a general way, just as we use the term "North American Indians." It is important that this terminology does not imply a single Mendelian population from the Arctic to the Rio Grande. Both in pre-contact times and since, the *real Americans* constituted a tremendous number of language groups, and a truly large number of populations separated by geographical, ecological and cultural barriers. Natural selection, migration, the "Founder effect," and classical Genetic Drift brought about the great genetic diversity, the extent of which we are only now becoming partially and slowly aware.

Such genetic diversity has major implications in terms of nutritional requirements for growth. Genetically larger individuals have demonstrably larger caloric and nutrient requirements, associated with both size attainment and more rapid growth rates, as can be shown within populations. Genetically smaller individuals, or those with a slower rate of growth, may survive under conditions of relative caloric malnutrition. Some of us feel that the small size of the Indians of the Altiplano constitutes genetic as well as physiological adaptation to poor-quality protein and limiting amino acids. Size differences in North American Indian children and adults therefore pose the dual problems of nutrition and genetics and considerably complicate the task of those currently engaged in nutritional evaluation. It is unlikely that a single set of height-weight-skeletal-dental standards can be used for Apache to Blackfoot through Mandan, Narragansett and Salish (11).

Medical geneticists, moreover, are encountering numerous population-limited developmental and metabolic abnormalities, as might be expected in relative genetic isolates. These include abnormalities of lipid metabolism in several groups, abnormalities of carbohydrate metabolism in such groups as the Pima, and abnormal glucose tolerance in the Cherokee Indians of North Carolina, to name a few (12).

Assuming the usual relationships between hyperglycemia, fat neonates, high perinatal mortality and subsequent mortality--it is clear that the nutritional problems we discuss broadly now will have to be elucidated for each American Indian nation. It is probable that "thrifty" genes may have held survival value in pre-contact times only to become inadaptive today.

GENETIC AFFINITIES WITH SOME ASIAN POPULATIONS

Although Columbus was convinced that he had come to the Indies (and early Protestant voyagers believed that they had discovered the "lost" tribes of Israel) the biological affinities of the American Indians are clearly closely linked to continental Asia. This is evident, superficially, in the histology and patterning of the terminal hair, in many quantitative dental traits, in the presence of Beta-AIB and Diego polymorphisms, and in brachymesophalangia (particularly brachymesophalangia 5) and cone-shaped epiphyses (13). At the same time the near-absence of blood groups B and N emphasizes the genetic diversities that time and geographical distance have introduced in the Americas.

Recently it has been shown that many African and Asian populations exhibit lactose malabsorption due to intestinal lactase deficiency (14). In affected adults, more than eight ounces of cow's milk per day may result in cramps and diarrhea. Although there are nongenetic causes of lactase deficiency, such as protein-calorie malnutrition, enteritis, gluten sensitivity, etc., lactase deficiency as seen in Japan and Thailand appears to be genetic in nature.

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The question of lactase deficiency in American Indians and Eskimos becomes an important one, bearing on the suitability of cow's milk as an adult food and among people who, in pre-contact days, rarely touched the stuff after weaning.

ECOLOGICAL AND NUTRITIONAL DIVERSITY IN PRE-CONTACT TIMES

Prior to Columbus, Henry Hudson and Roger Williams, ecological and nutritional diversity among American Indians was tremendous. Wild rice, sunflower seeds, pinon nuts, and maize (among other seed staples) created great diversity in these respects, and with some interesting questions of digestibility (except where well pounded, thoroughly ground and well cooked). Roots and shoots and greens, particularly as bulk agents, may have been sources of vitamin C, and at the same time, contributors to intestinal activity and consequent loss of protein. And there was geophagia (15).

Such ecological diversity makes it difficult to generalize about previous nutrition and malnutrition in American Indians. The one certain generalization is that milk, other than human, was not employed. A second generalization is that probably no American Indian group experienced the low-calcium intakes of people in Indonesia and Java and Hong Kong today. Fish-eating Indians on both maritime coasts consumed grams of bone with their meals, and shellfish eaters made stews often resembling rich mortar. Only the Plains Indians, post-contact, were in a position to have a low-calcium diet, and only for a limited number of years, until they were literally railroaded out of existence.

From what we can recreate, Amerindian nutritional diversity was such as to make seasonal caloric malnutrition more likely than classical protein-caloric malnutrition. Even the maize eaters did not achieve the yellow-maize exclusiveness of post-contact Central America. Vitamin C deficiency was possible on a seasonal basis, northward in increasing proportion to the length of the winter. Vitamin A deficiency probably was more seasonal than not, as were deficiencies of some of the B vitamins.

Inescapably, iodine-deficiency states must have existed in the Great Lakes region and elsewhere, as was also experienced by the later European settlers, and vitamin D deficiency must have had a seasonal basis--except perhaps in some maritime groups.

Lacking food transport, some trace element deficiencies presumably existed--fluoride, for example, in the Upper Great Lakes region, New England, etc., but with less necrotic consequences than today perhaps because of the lower sucrose intakes. At the same time, the lack of imported food dilutants, must have resulted in extremely high fluoride intakes in some areas, high calcium intakes in others, but with limitations due to oxylates in greens and shoots.

POST-CONTACT FOOD ACCULTURATION AND ITS PRESUMPTIVE RELATIONSHIP TO NEW FORMS OF MALNUTRITION

All North American natives that I know of, including Arctic-adapted groups, have been subject to extensive food acculturation in their post-contact experience. This has resulted from a) loss of lands, b) disappearance of game, and c) hunting restrictions. Food acculturation has been a simple survival necessity in forced relocation. It has been taught and it has been enforced, and it has come again in the wake of modern food technology, advertising and mass (but selective) distribution.

Unfortunately, the new foods acquired have been poor replacements in many cases. Flour, sugar, coffee, salt, and lard came in the wake of trading-posts and army sutlers. Pop, Kool-Aid, candy and crackers arrived ahead of other recent food additions. Hunters, traders, army cooks and early school teachers were hardly carriers of nutritional knowledge, nor are trading-post operators and native storekeepers today. What we have given to the American Indians and Eskimo is Western caloric staples, without nutritional knowledge. In the form of soda pop, crackers, candy and fats this old tradition continues.

Other aspects of food acculturation include early weaning, and a decrease in breast-feeding, without equal access to safe quality-protein replacements for breast milk in many cases. Candy, pop and crackers became both rewards and staples, without equal emphasis on fruits, vegetables, and oral hygiene.

Food acculturation, therefore, has been nutritionally bad, obviously so for the enamel of the teeth, for gingival integrity and that of the supporting bone. Early weaning has opened the door for protein-caloric malnutrition, especially where sugars have been employed to achieve caloric density. There has been a cultural gap between the older use of shoots and roots and berries and obtaining vitamin C from juices and imported fruits, both of which are expensive on the reservation and in the village store.

Food acculturation is probably irreversible. Nutritional knowledge is not. Forms of malnutrition that came in the wake of food acculturation are more than theoretically reversible. Things go better without Coca-Cola, if nutritional knowledge can be a part of nutritional improvement. Without better nutritional knowlege we still have the potentiality for 19th Century vitamin deficiencies, including deficiency of vitamin C, deficiencies of quality protein in the preschool children, and certainly for hypovitaminosis-D and -A and other additional possibilities where geophagia still exists.

PROGRAM FOR ACTION

Malnutrition is reversible, though not in a single generation. To reverse malnutrition there must be a selective decrease in energy loss

during childhood. To reverse malnutrition there must be improvements in nutritional knowledge to an operational level of informed dietary planning. Nutritional advice and nutritional programs must be locally-applicable, geared to local lacks and local methods of food preparation and serving.

The reversal of malnutrition must be measured. There is even now evidence of an increased body size in some North American native groups (16). Such information is needed for other groups and it can be acquired, analyzed and reported at the local level. The reversal of malnutrition is important not just to those of us who study malnutrition and its limiting effects on growth, reproduction and aging, but even more to the people themselves, who have major stakes in their own nutritional past, present and future.

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NEUROLOGICAL CORRELATES OF MALNUTRITION IN ANIMALS AND MAN

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Undernutrition during the growing years leaves in its wake thin, stunted children with reduced cranial volumes and reduced anthropomorphic measurements (1). The earlier the onset of malnutrition, the more severe the growth retardation and the less likely the child is to recover even if subsequently adequately nourished.

Animal data support these clinical observations and suggest a precise time-dependency of events in the various species studied. Protein-calorie restriction in rats from birth to weaning will result in animals who are lighter at the time of weaning and who never recover normal weight even if subsequently fed adequately (2). In addition, length and cranial volume are reduced in these animals. All of these changes persist throughout life. In contrast, animals malnourished toward the end of the growing period are smaller at the end of the period of restriction but recover normal size if subsequently adequately re-fed (3). All of these observations suggest that the time during which nutritional deprivation occurs may be a critical factor in determining whether recovery will follow. These data raise an obvious question: What is different about early growth in contrast to later growth which renders an animal or child unable to recover from a period of malnutrition?

An answer to this question is suggested if one dissects growth into certain component parts. Any organism or individual organ may grow by increasing the number of cells or by increasing the size of each in-

dividual cell, or by both. Since the quantity of DNA is constant within the nucleus of all diploid cells within a given species, the amount of DNA in any organ at any time reflects the number of cells within that organ (4). Hence, determining the organ DNA content over time will measure growth by increase in cell number (5). In fact, the actual number of cells may be calculated by dividing the total organ DNA content by the DNA content per diploid cell in the particular species under investigation, i.e., 6.2 pica grams in the rat, 6.0 pica grams in the human. Once the number of cells is determined, then the "average" weight per cell or protein content per cell may be determined simply by weighing the organ or determining its total protein content and then dividing by the number of cells. These are estimations of average cell size. In chemical terms, then, total organ DNA reflects cell number, and weight/DNA or protein/DNA reflect cell size. Similarly any intracellular substance divided by the DNA content, e.g., RNA/DNA, reflects the quantity of the substance per cell.

In brain, like any other organ, DNA synthesis, and hence cell division, stops long before growth stops. In the rat, both serial analysis of DNA and incorporation studies with C14 thymidine indicate that cell division stops at about 20 days postnatally (5,6). In the mouse, DNA synthesis stops one or two days earlier (7,8). In the human, analyses of total brain DNA content from therapeutic abortions and from children who died of accidents, poisonings, or crib deaths demonstrate that cell division slows down around birth, but continues until 10 months of age, after which there is very little increase in the total number of brain cells (Fig. 1) (9).

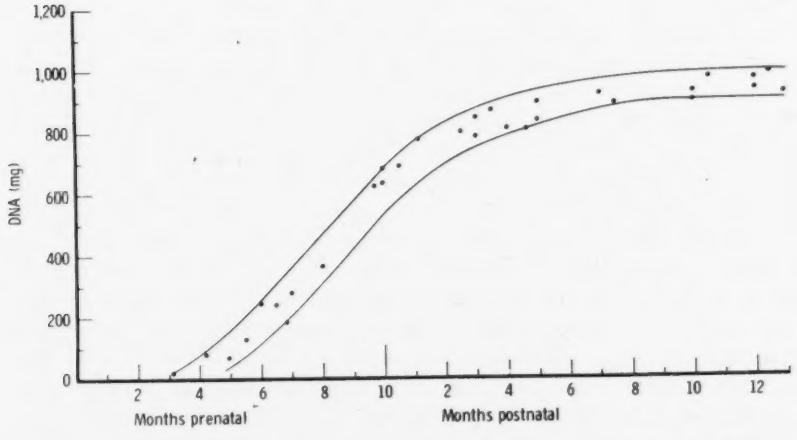

Figure 1: Total DNA content of human brain derived from 31 cases of therapeutic abortions, crib deaths, accidental deaths and poisonings. (*From Winick, M.: Ped. Res. 2: 352, 1968.*)

In contrast, net protein synthesis continues throughout the growing period (Fig. 2). As a result, although the final size of the brain, or any other organ, may be expressed by its ultimate weight and protein content, the manner in which this protein will be packaged will change during the growing period. During the period of DNA synthesis, when cells are dividing rapidly, cell number increases and cell size remains constant (hyperplasia). As the rate of cell division slows, the size of individual cells increases, and finally as a consequence of the cessation of cell division, all growth is by enlargement of individual cells (hypertrophy). Thus one can describe three phases of cellular growth in any organ: hyperplasia; hyperplasia and concomitant hypertrophy; and hypertrophy alone. These three phases are due not to any changes in the rate of net protein synthesis, which continues at the the same rate, but rather to a slowing and finally a cessation of cell division.

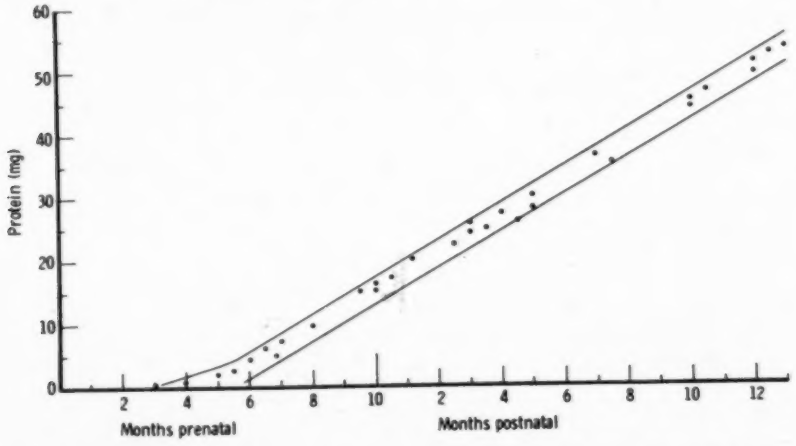

Figure 2: Total protein content of human brain derived from 31 cases of therapeutic abortions, crib deaths, accidental deaths and poisonings. (*From Winick, M.: Ped. Res. 2: 352, 1968.*)

BRAIN GROWTH AND THE EFFECTS OF NUTRITION

Brain, however, is not a homogenous organ. It is composed of various regions, each made up of different cell types, each controlling different functions. Each of these regions shows its own specific pattern of cell division. During postnatal growth, rat cerebellum rapidly increases in cell number until 17 days. Cerebral cortex increases more slowly until 21 days, whereas cell division ceases in brain stem at about 14 days. During part of this period (14-17 days) cells are also migrating from under the lateral ventricle to the hippocampus (Fig. 3) (10). Radioautographic studies indicate that this migration is specifically restricted to the 15th day of life (11). During prenatal life all regions studied are

growing by hyperplasia. The rate of cell division is particularly rapid in cerebellum and in the area adjacent to the lateral ventricle.

The types of cells dividing differ in the different areas. In cerebrum, only glia multiply postnatally, whereas in cerebellum both neurones and glia multiply until at least 10 days after birth. During this period of cellular proliferation in brain, the rate of myelin synthesis is extremely rapid. In the rat, the most rapid phase of myelination is from 10 to 21 days. Incorporation of sulphate and galactose into cerebrosides and the entry of preformed cholesterol and of cholesterol precursors into brain in vivo are maximal during this period. The same is true of in vitro incorporation of phosphatide precursors into myelin phospholipids (12). Since the rate of total myelin synthesis must depend, in part at least, on the number of oligodendroglia, the cells which synthesize myelin, total lipid content will depend partly on DNA content.

Caloric restriction immediately after weaning results in a reduction in brain cell size as reflected in a reduced protein/DNA ratio. The

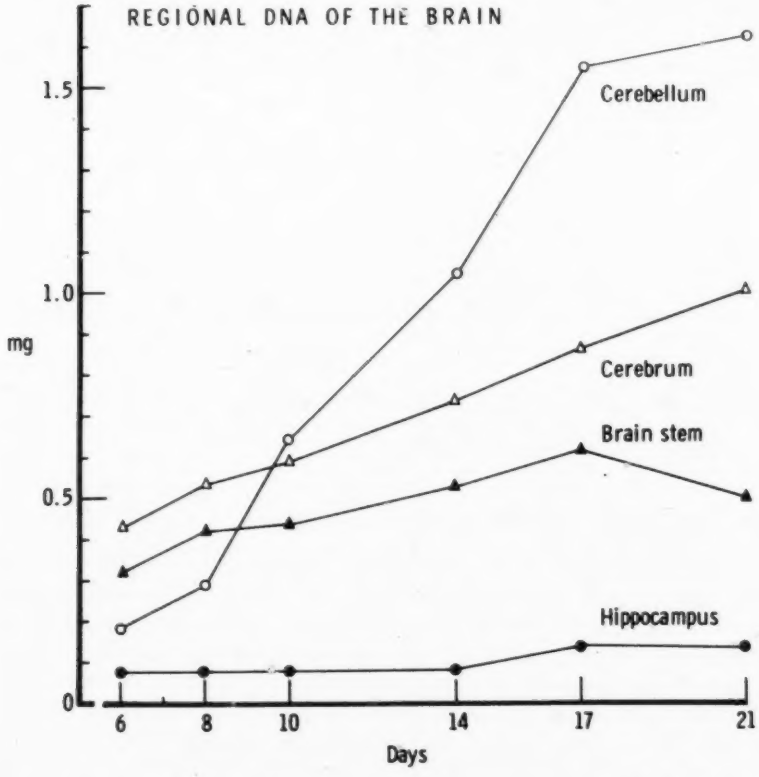

Figure 3: Total DNA content in various regions of rat brain. (*Winick, M.: Fed. Proc. 29: 1510, 1970.*)

number of cells remains normal, the restriction having been started after cell division in the brain had already stopped. Reduction of total calories from birth to weaning retards the rate of cell division and results in a permanent deficit in the total number of brain cells (13,14). Either caloric restriction (15) or severe protein restriction during gestation also reduces the number of brain cells at birth. If an animal is exposed to both prenatal and postnatal malnutrition, a much greater deficit in total brain cell number occurs by the time of weaning than would be expected simply from adding the prenatal and postnatal effects (Fig. 4). Thus malnutrition at any time during the period when cells are dividing curtails the rate of cell division and results in fewer total brain cells. Malnutrition after cell division has stopped affects cell size, and this is reversible. The data also suggest that in addition to the time at which malnutrition begins, the duration of malnutrition is also

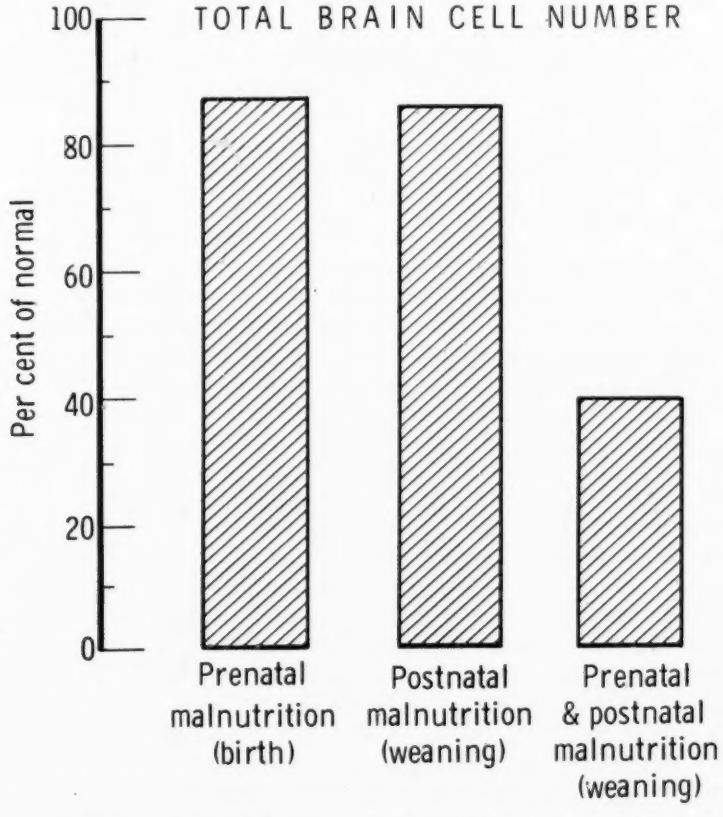

Figure 4: Comparison of caloric restriction after birth, protein restriction during gestation and "combined" prenatal and postnatal restriction. (*From Winick, M.: Ped. Clin. No. Amer. 17: 69, 1970.*)

important during this critical period of rapid cellular proliferation.

Increasing the number of calories and/or the amount of protein will increase the rate of cell division, and result in permanent increase in brain cell number, again only if this caloric increase is begun during the period of cellular proliferation. This had been demonstrated directly in the postnatal period by reducing the number of nursing pups (17), and indirectly in utero by artificially reducing litter size (18). Thus, within certain limits, the number of cells which ultimately will be present in adult brain can be programmed during prenatal and early postnatal life. One important agent in this programming is the state of nutrition. The data also suggest that if reversal of retarded cell division imposed by malnutrition is to occur, rehabilitation must begin early enough during the phase of cellular proliferation to allow time for realteration of the rate of cell division and ultimate attainment of normal cell number. Experiments in rats in which cell division has been retarded by early caloric restriction from birth to nine days of age and then accelerated by "super feeding" until weaning have demonstrated that the deficit which occurs in the first nine days can be completely made up (19).

Specific regions are preferentially affected by undernutrition. If malnutrition begins at birth, a reduction in total DNA content in cerebellum becomes apparent by eight days of age. In contrast, cerebral cortex is not affected until 14 days. In hippocampus, the migration of cells normally seen at 15 days of age is delayed (Fig. 5). Differential regional sensitivity can also be demonstrated in utero by the 16th day of gestation in the brains of fetuses of protein-restricted mothers. The cerebral white and gray matter are only mildly affected. The area adjacent to the third ventricle and the subiculum are moderately affected, whereas the cerebellum and the area directly adjacent to the lateral ventricle are markedly affected. These data demonstrate that the magnitude of the effect produced on cell division is directly related to the actual rate of cell division at the time the stimulus is applied.

This retardation of cell division will affect any cell type in the process of dividing. By employing radioautography and counting the percentage of different cell types which are labelled, it is possible to count the number of neurones, glia, and primitive cells which have divided in the previous 24 hours. Animals malnourished from birth were examined at 10 days of age. In cerebrum, neurones do not divide postnatally and are therefore not affected by postnatal malnutrition. In cerebellum, both neuronal and glial proliferation are retarded by postnatal malnutrition. The internal granular cells which are to be neurones, the external granular cells which may differentiate into either neurones or glia, and the so-called molecular cells are all reduced in number. The number of cells migrating from under the lateral ventricle into the hippocampus is reduced (Fig. 5). This reduction is probably due to an inter-

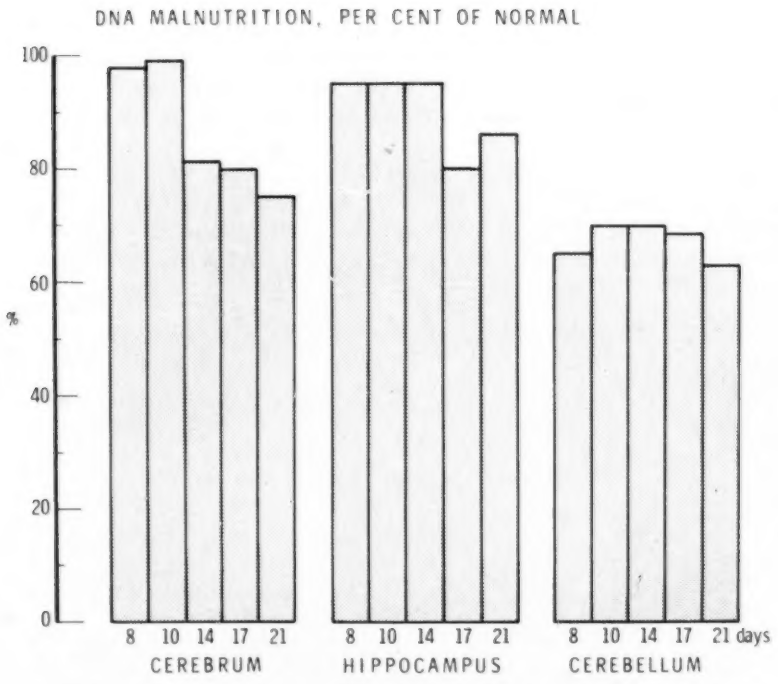

Figure 5: Effect of neonatal caloric restriction on total DNA content of various brain regions. (*From Winick, M.: 74: 667, 1969.*)

ference with cell division in the primitive cells under the lateral ventricle; it is most marked posteriorly where cell division is normally quite rapid. Cell division can also be seen to be slowed in the undifferentiated cells under the third ventricle. Thus a variety of "cell types" in these different areas are dividing postnatally, and the rate of cell division is curtailed by malnutrition in all of these cell types.

SYNTHESIS OF LIPIDS AND DNA IN BRAIN AND THE EFFECTS OF MALNUTRITION

In rats, malnutrition during the first three weeks of life has been shown to interfere with the synthesis of lipids. There is a substantial deficit in total brain cholesterol, and there is a lowering of cholesterol concentration (20). In pigs malnourished during the first year of life, total brain cholesterol and phospholipid content are markedly reduced, and cholesterol concentration is slightly reduced (21). These changes, both in rats and in pigs, persist even when the animals are rehabilitated for a long period. More recently it has been demonstrated that incorporation of sulfatide into myelin of rat brain is reduced both in vivo and in vitro by malnutrition during the first three weeks of life. Moreover,

the activity of galactoscerebroside sulfokinase, the enzyme responsible for this incorporation, is reduced during malnutrition (22). Although the reduced lipid content could be due to a reduction in the number of oligodendroglia, the enzymatic data suggest that lipid synthesis per cell may also be reduced.

These data from animals suggest that if malnutrition is to curtail cell division permanently in the human brain, it would have to be imposed during the period of active cellular proliferation. This period extends throughout prenatal life and during the first six months of postnatal life (9).

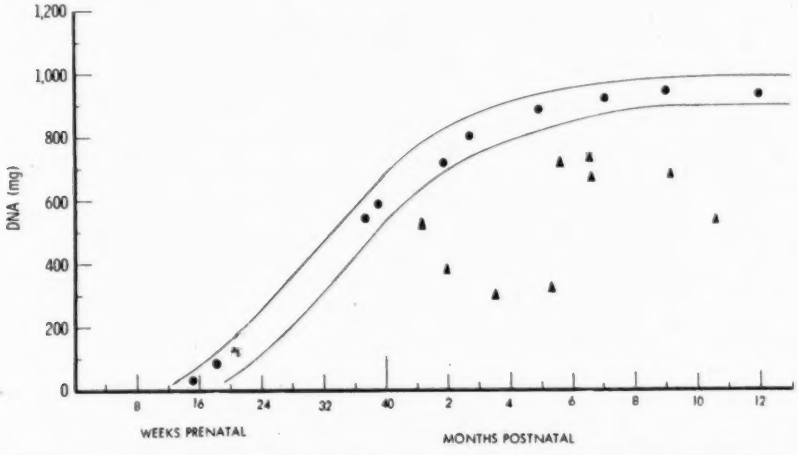

Figure 6: Lines indicate U.S. Norms, circles indicate normal Chilean brains, triangles indicate brains of Chilean children who died of marasmus. (*From Winick, M. and P. Rosso: Ped. Res. 3: 181, 1969.*)

In a study carried out at the Hospital Roberto Del Rio of the University of Chile in Santiago, Chile, the brains of nine infants who died of severe malnutrition during the first year of life were examined. In every case, DNA content of whole brain was significantly reduced (Fig. 6) (23). In three of the infants, all of whom weighed less than 2,000 gms at birth, there were only 40% of the expected number of brain cells. These were either premature infants whose brains were exposed to malnutrition at a time they still should have been in utero, or they were "small for dates" babies whose brain growth was retarded in utero, perhaps by maternal malnutrition. In either case, the data demonstrate that the small newborn may be more at risk than the large newborn. By the time of death the brains of these infants showed a reduced DNA content similar to the reduction seen in the "doubly deprived" rat.

MATERNAL UNDERNUTRITION

That malnutrition of the mother in humans will retard fetal growth is suggested by a number of studies. First, the data from Rotterdam

and the Hague showed that infants whose mothers were pregnant during the famine had smaller babies (24). Studies during the seige of Leningrad confirmed these findings (25). Secondly, placentas from infants who are too small for their gestational age showed a reduced number of cells and an elevated RNA/DNA ratio (26). Placentas from an indigent population in Chile showed similar findings (27), and placentas from a malnourished population in Guatamala also showed a reduced number of cells when compared with a well nourished population from Iowa City (28). Finally, in a single case of anorexia nervosa in which an 85-pound mother gained no weight during pregnancy and gave birth to a full-term infant, weighing 2,200 gms, the placenta showed a 50% reduction in total cell number (Fig. 7).

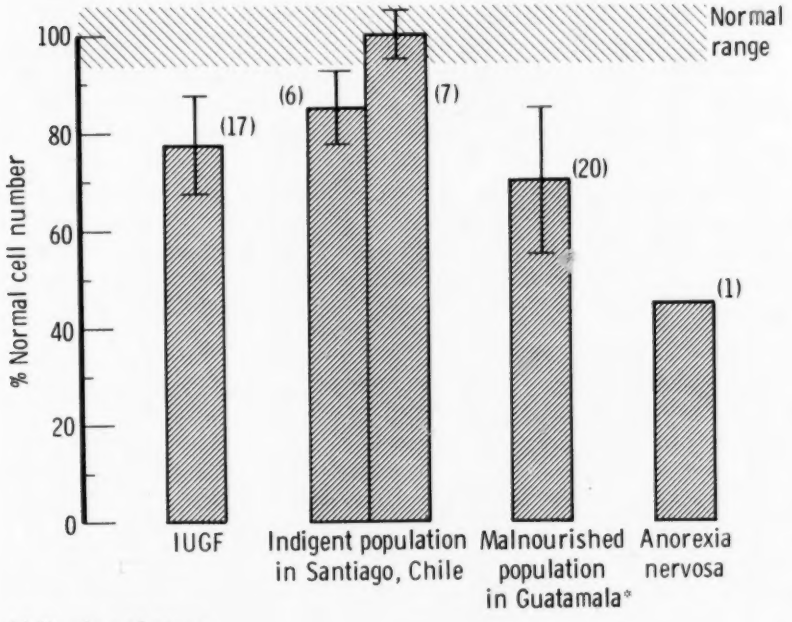

Figure 7: Placental cell number in various types of maternal undernutrition. (*From Winick, M.: Ped. Clin. No. Amer. 17: 69, 1970.*)

Thus it would appear that fetal growth retardation secondary to maternal undernutrition can occur in humans, and the placenta in these cases has a marked reduction in cell number. In animals, as previously described, brain cell number is also reduced.

MALNUTRITION IN EARLY CHILDHOOD

In older children, i.e., breast-fed and then malnourished after one year of age, preliminary data collected in collaboration with Dr. John

Waterlow of Jamaica indicate that the number of brain cells is normal and the size of the individual cells is markedly reduced. Thus the data in humans, although still only fragmentary, support the animal studies and suggest that severe malnutrition will curtail cell division both in utero and in early postnatal life in those organs undergoing rapid proliferation. Later malnutrition will curtail the increase in cell size which normally occurs after the proliferative phase. If the animal studies can be further extended, then presumably the findings will be substantiated that the deficit in cell number will be permanent, whereas the reduced cell size will be reversible. Studies by Miller (29) have demonstrated that protein is the limiting nutrient during malnutrition. The reduced availability of amino acids slows the rate of net protein synthesis and limits growth. In the young animal, cell division is also curtailed.

In the few cases of kwashiorkor occurring during the first year of life in which we have been able to study the brain, cell number was reduced. These data suggest that it is not the type of malnutrition, but rather the time it is active, which is critical. Both marasmus and kwashiorkor produce a cellular deficit in brain during the first year of life.

It is possible, on the basis of the cellular changes in brain, to separate malnourished children into three groups (Fig. 8): 1. Low birth weight--malnourished during the first year. Marked reduction in brain cell number; 2. Normal birth weight--malnourished during the first year. Moderate reduction in brain cell number; and 3. Normal birth weight--

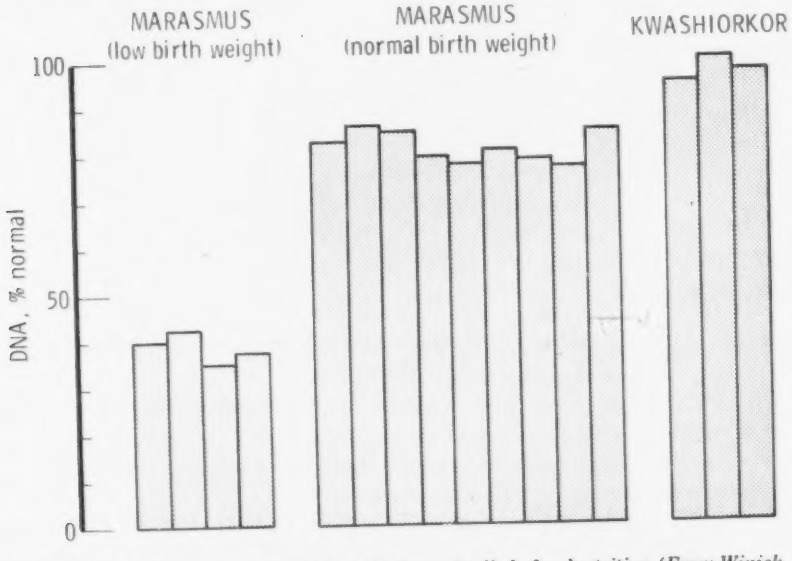

Figure 8: Total DNA content in brains of children who died of malnutrition. (*From Winick, M.: Ped. Clin. No. Amer. 17: 69, 1970.*)

malnourished during the second year. No reduction in brain cell number.

SUMMARY

Early malnutrition in rats retards cell division in any brain area in which proliferation is occurring and permanently affects any cell type which is proliferating. Migration of cells is delayed, and the synthesis of myelin is retarded. In humans also, cell division is curtailed by early malnutrition. Later malnutrition will reduce the size of individual cells, but not the number of cells. Studies of human placentas suggest that maternal malnutrition will curtail cell division in that organ and retard overall fetal growth. The mechanism by which the same stimulus, i.e., malnutrition, affects cell division at one time and cell size at another is at present speculative.

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BEHAVIORAL CORRELATES OF SEVERE MALNUTRITION IN MAN

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Recently, review papers (1-3) on nutrition and learning have underscored the effects of early protein-calorie deficiency on the structure, maturation and growth of the brain, pointing out the likelihood of a loss in learning ability as a sequel to malnutrition. A word of caution, however, generally has been added to these data since present information on the biological basis of intelligence is not sufficient to single out the histological, biochemical and physiological changes that must occur in the brain to affect learning. There is no conclusive evidence, for example, that either a slow rate of biochemical maturation or a comparatively small brain at maturity, like that found in malnourished children (4,5), is detrimental to intelligence. Moreover, although the data on malnutrition and neural growth have descriptive and heuristic value, they do not warrant specific conclusions on the relationship between malnutrition and behavior.

Information on the organic changes that accompany severe nutritional deficit, therefore, must be supplemented with data from behavioral research to determine whether the biological deficits correspond with impaired learning ability. Evaluation of the level of intellectual functioning of children with histories of protein-calorie malnutrition would appear to be a good method to determine whether behavior is actually affected. Paradoxically, however, past and ongoing behavioral research might not be able to clarify what specific effects, if any, nutritional deficit has on learning. Malnutrition is defined as a state of faulty

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or imperfect nutrition, but it is by no means only that, especially when it exists in a human infant. Infantile malnutrition--particularly nutritional marasmus--is a condition which develops both as the result of a deficient diet and by the action of various adverse biological and social factors like infections or poor child-rearing practices (6-8). Furthermore, severe nutritional deficit is likely to be associated with serious deficits in environmental stimulation and maternal attention and protection. The apathetic, listless state resulting from nutritional deficiency does not allow the infant to respond to the stimuli that surround him (9,10). Severe protein-calorie deficiency therefore defines a nutritional condition, but also describes an overall condition of biological and psychological misery and deprivation.

Given the nature of the adverse variables contributing to the development of the nutritional deficit, as well as the associated environmental deprivation, one seems safe in assuming that the learning ability of a child with a history of malnutrition is likely to have been affected by a whole cluster of bio-social factors, only one of which is nutrition. If one were to measure the specific effects of the nutritional factor, it would be necessary to control all related variables, that is, the actions of antecedent factors as well as those of existing conditions of deprivation.

Information from past behavioral research (11-19) based on a retrospective approach does not lend itself particularly well to the specific determination of the contributory effects of the antecedent and existing detrimental variables. Simple developmental evaluations of children both with and without histories of protein-calorie malnutrition cannot ascertain the principal co-determinants of the observable differences between the two groups of children. This type of data seems significant only if used to indicate the level of intellectual functioning or learning ability of children having experienced the adverse effects of severe malnutrition and of the other related detrimental factors in early life.

The problems of retrospective studies would seem to be obviated by using a prospective approach. Accounting for the related biological and social variables could presumably isolate the specific effects of the nutritional deficit. This approach, moreover, presumably allows the identification and possible control of adverse factors that could appear during the course of the child's development. However, some variables cannot be controlled, especially those that co-exist with the nutritional deficit, such as the state of environmental deprivation on the child. Both are likely to have an additive or interactive effect which could hardly be separated even by a prospective design.

Prospective studies, in addition, have a built-in methodological limitation that should also be considered (20). The initial contact with the group of people studied and the experience associated with the evaluative procedures will probably affect the subject. It seems unlikely that one could select a specific sample of families and children and ob-

tain a developmental baseline without changing their original status to some degree. This intervention effect, indeed, might appear even greater if one were to assess the development of the relationships among the related biological and social factors and the nutritional history of the family and child.

Thus, it appears that behavioral research on the relationships between malnutrition and learning ability or intellectual functioning cannot have the degree of specificity found in parallel studies of organic changes. Behavioral research might be able to control for some of the antecedent variables of malnutrition, but it can only determine the effects of the nutritional factor within the context of a more global impact.

DIFFERENCES IN CONDITIONS OF MALNUTRITION

Analysis of the general conditions of severe protein-calorie malnutrition among children also emphasizes that this disease cannot be considered on the same scale as milder forms of nutritional deficiency when it is being studied for its effects on learning ability. The close relationship between severe protein-calorie deficiency and adverse biological and social variables that co-exist with a state of environmental deprivation point out that this condition has its own characteristics absent in milder forms. Moderately malnourished children do not suffer the effects of the adverse variables found in severely malnourished children. An illustration of this difference is seen in the mother-child interaction in moderate and severe cases of malnutrition. While in severe nutritional deficiency there is likely to be a schism in the expected pattern of reciprocal stimulation between mother and child (21), such a schism is not necessarily found in children with moderate malnutrition. In populations where moderate malnutrition is prevalent during the first three years of life, the effects of undernutrition could limit the responsiveness of the child to the mother; however, this lower level of arousal is likely to be an expected form of behavior among these children. Therefore, although mother-child interaction might be influenced by nutrition, it still would follow the expected pattern of the particular group.

Because of the different biological and social factors affecting children with varying nutritional deficiencies, even if there were evidence of irreversible intellectual damage in the child who has had severe protein-calorie deficiency, this should not necessarily suggest that similar damage occurs in milder conditions of malnutrition. Therefore, since the conditions differ in nature, they cannot be considered simple variations on a single continuum.

STUDIES OF CHILDREN WITH SEVERE MALNUTRITION

Having placed the behavioral data on children with protein-calorie deficiency in perspective, we can selectively review investigations on the intellectual development of severely malnourished children. Seven

studies have been selected on the basis of the following criteria: first, they included only children who had been hospitalized because of their nutritional condition; second, the nutritional deficiency was specifically defined as nutritional marasmus or kwashiorkor; third, the data from the results of the psychological evaluations were presented in quantitative terms; and fourth, the data reported did not present internal inconsistencies.

The selected studies can be separated into two groups: four including children with nutritional marasmus (11-14) and three including children with kwashiorkor (15-17). Behavioral data had been collected, in some of the studies reviewed, both during and after the children were nutritionally rehabilitated. The data discussed here, however, include only the last reported assessment, assuming that the last evaluation would yield the best prognostic measure of rehabilitation. The shortest interval between the period of hospitalization and assessment was between 6 and 12 months.

It is worth noting that little, if any, information is available on the children's developmental condition prior to their malnutrition, on their family environment, or on the conditions and length of hospitalization. Given that common characteristic, however, it is likely that there are major differences in some of the variables among the selected studies. For example, children in two studies (11,14) were hospitalized for about one year, while those in another study were in the hospital less than 12 weeks. It is also worth noting that the associations existing between malnutrition and adverse bio-social variables increase the likelihood of finding some degree of intellectual impairment among these children. Hence, if one were to find that at least some of these children were not impaired, there would be good reason to doubt that the nutritional deficit affected learning ability of the particular subjects.

Nutritional Marasmus

The four studies on nutritional marasmus include two done in Peru by Brockman (11) and by Pollitt and Granoff (14), one in Yugoslavia by Cabak and Najdanvic (12), and one in Chile by Monckeberg (13) (Table 1). Both Peruvian studies were conducted at the British American Hospital in Lima within a relatively short time of each other so there is considerable overlap in the children studied. Although the investigators used different tests the results in the two studies were quite similar. Therefore, I will review only one of them (11), with simply an excerpt from the other (14) to illustrate the magnitude of retardation among these subjects.

TABLE 1

Summary of Behavioral Studies of Children with Nutritional Marasmus

Investigator	Number and description of nutritional condition of experimental Ss	Age of experimental Ss at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Brockman (11)	(N = 20) 1. Diagnosed as marasmus 2. Body weight less than 50% of expected for age 3. Free of apparent edema 4. Normal serum albumin	Mean of 10 younger children: 9.2 mos. Mean of 10 older children: 16.2 mos.	(N = 19) 1. Matched for sex and age with patients 2. Attended regularly day care centers of Lima slums 3. Body length at or above 10th percentile ot Boston growth curves	Experimental: Mean of 10 younger children: 17.9 mos. Mean of 10 older children: 34.9 mos. Controls: Mean of 9 younger children: 18.7 mos. Mean of 10 older children: 33.8 mos.	Categorization behavior through 10 sorting tasks of 8 objects each	Average test scores Ss <24 mos. Ss >24 mos. Exp. 9.2—20.0 Cont. 21.0—40.0
Monckeberg (13)	(N = 14) Severe marasmic malnutrition	Range: 3–11 mos. Mean: 6.2 mos.		Range 3–6 yrs.	"Binet Method": Intelligence Quotient	Mean IQ: 62 No child with IQ above 76

TABLE 1—Continued

Summary of Behavioral Studies of Children with Nutritional Marasmus

Investigator	Number and description of nutritional condition of experimental Ss	Age of experimental Ss at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Cabak and Najdanvic (12)	(N = 36) 1. Marasmus 2. Slight edema present in a few 3. 27% or below the correct weight for their age 4. No TB or diseases of the central nervous system	Range: 4–24 mos. Most of the cases were below 12 mos.		Range: 7–14 yrs.	Adaptation of the Binet-Simon Scale: Intelligence Quotient	Mean IQ: 88 IQ Frequency Distribution: N — IQ Range 18 — 91—110 12 — 71— 90 6 — ≤ 70 Mean IQ of children from 2 nearby communities: 101 and 109.
Pollitt and Granoff (14)	(N = 19) 1. Weight deficit of 40% or more for age 2. Free from edema 3. Normal serum albumin	Range: 6–8 mos. Mean: 16 mos.	(N = 28) 1. Siblings of patients 2. No history of malnutrition	Experiment: Range: 11–32 mos. Mean: 22 mos. Control: Range: 3–30 mos. Mean: 9 mos.	Bayley Scales of mental and motor development: Mental Development Quotient Motor Development Quotient	Results reported on mean sigma scores Mental Scale — Motor Scale Exp. −4.05 — −3.76 Cont. −0.70 — −0.50

Brockman (11), Cabak and Najdanvic (12), and Monckeberg (13) studied a total of 70 children diagnosed as having nutritional marasmus with severe deficits in height and weight. At the time of the psychological evaluations, the children from the studies of Brockman and Monckeberg were preschoolers, some of whom were still hospitalized. The study by Cabak and Najdanvic, on the other hand, was done many years after the nutritional condition while the children were attending primary school.

In all three studies, the psychological tests used were instruments that theoretically assess precursors of later intellectual functioning or basic cognitive processes. Monckeberg used the Gesell Schedules and the Stanford Binet Intelligence Scale; the latter test was also used by Cabak and Najdanvic. Brockman administered a more specific test of sorting and manipulative behavior, presumably assessing non-verbal concept formation.

Data from the two Latin American investigations showed a striking degree of retardation in the preschool children (11,13). Both studies indicated that the children were functioning almost 50% below the level expected for their chronological age. Brockman, for example, found that the categorization behavior of the 10 older malnourished subjects, with a mean age of 34.9 months, was similar to that in the younger control children who had a mean age of only 18.7 months. It should be emphasized that in Brockman's study the degree of retardation was not suggested by a comparison with American norms but with children from low socioeconomic status living in the same areas as the experimental subjects. Moreover, the test used in this study probably is less influenced by so-called cultural factors than other tests, thus suggesting the existence of a basic cognitive difference between the groups assessed. Pollitt and Granoff (14) in describing the degree of retardation found in these children stated, "With the exception of one child, 28 months old, the age range of the seven remaining children tested in the Metabolic Ward sample was 11 to 16 months. It would be expected that these seven children would pass mental and motor scale items at a level approximating their chronological ages, even taking into consideration errors arising from the cultural differences between the present sample and the American norms. However, none of the seven children passed items from the motor scale above the 8.6-month level. When the individual items were considered, no child from the group would accomplish, for example 'stepping movements,' passed normally at 9.2 months. Moreover, only one of the seven could 'stand up' (8.4 months), and this same child was the only one who could 'raise himself to sitting position' (8.2 months). Again considering the same seven children, none was able to 'vocalize four different syllables' an item expected in a 7.4-month-old child; none could say 'dada' or equivalent (8.5 months)."

By contrast, the evaluation of older subjects by Cabak and Najdanvic showed, on the average, only a mild degree of retardation among the

subjects (12). Actually, half of the sample of 36 children obtained intelligence quotients (IQ) falling within the normal range of the classification system. Moreover, only six children fell in the defective range (IQ less than 70). It should be noted, nevertheless, that the IQ distribution was negatively skewed in comparison with that for Serbian children in general.

The difference between the results from the Monckeberg and Brockman studies, on the one hand, and the study of Cabak and Najdanvic, on the other, suggests the possibility in the older children that retardation ameliorated with age, and that the initial damage was actually reversible. The possibility of reversibility, however, is not supported by the non-significant correlation between length of hospitalization and cognitive test performance found by Brockman. She also found no improvement in test scores between two similar evaluations done three months apart.

Possibly the difference between the data from the Latin American studies (11,13) and the results from some of the patients in the Yugoslavian study (12) could be related to a difference in the severity of the initial physical condition of the children. All the cases included in the Monckeberg and Brockman studies were 40 to 50% below the weight measurements expected for their age whereas some of Cabak's and Najdanvic's patients were only 27% below their expected weight for age. Cabak and Najdanvic found also a significant negative correlation between weight at hospitalization and test performance. It is then clear that the severity of the physical deficit is an important dimension in the prognosis of the child's intellectual development: the more severe the weight deficit, the less likely it is for the child to be intellectually intact and the greater the probability that he will be impaired.

Kwashiorkor

The studies on children with kwashiorkor include one by Champakam, Srikantia and Gopalan (15) in India, another by Cravioto and Robles (16) in Mexico and a third by Hansen, Freesemann, Moodie and Evans in South Africa (17) (Table 2). Another study, by Barrera-Moncada in Venezuela (18), which also assessed the mental development of children rehabilitated from kwashiorkor has not been included in this group because of inconsistencies in the data reported. Still the results of this study are included on Table 2. A total of 79 children represent the number of cases in the three investigations reviewed. With the exception of the children studied by Cravioto and Robles, evaluated at preschool age, the children in the three other studies were of school age at the time of the psychological assessment. The Indian children were--on the average--9.2 years old while the mean age of the South African children was 11.6 years.

TABLE 2
Summary of Behavioral Studies of Children with kwaskiorkor

Investigator	Number and description of nutritional condition of experimental Ss	Age of experimental Ss at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Champakam, Srikantia and Gopalan (15)	(N = 19) "Classical signs of kwashiorkor"	Range: 18–36 mos. Mean: 27.1 mos.	(N = 50) Control matched for 1. Age 2. Sex 3. Religion 4. Caste 5. SES 6. Family size	Experimental: Range: 8–11 yrs. Mean: 9.2 yrs. Control: Range: 8–11 yrs. Mean: 10.1 yrs.	1. Object assembly 2. Immediate memory 3. Block designs 4. Digit recall 5. Comprehension 6. Picture arrangement Intersensory Development: 1. visual-haptic 2. visual-kinesthesic 3. haptic kinesthesic	Significant difference in all areas assessed between experimental and control Ss. Greatest difference in abstract and perceptual abilities. Difference between groups decreased as age increased. Performance of exp. children expressed as % of the controls. Age, years — No. — Mean 8-9 — 11 — 31.30 9-10 — 5 — 54.45 10-11 — 3 — 52.44

TABLE 2—Continued

Summary of Behavioral Studies of Children with kwaskiorkor

Investigator	Number and description of nutritional condition of experimental Ss	Age of experimental Ss at time of hospital admission	Number and description of control Ss (if any)	Age of experimental and control Ss at evaluation	Test used and type of measure obtained	Results
Cravioto and Robles (16)	(N = 20) 1. Third degree protein calorie malnutrition. 2. Presence of edema.	Range: 6–30 mos.		1 yr. after hospitalization	Gesell schedules: Developmental Quotients	A difference existed in performance between younger and older Ss. In the young (6 mos.) the gap between norms and performance widens with increased hospitalization. Severe retardation is found in language areas. In the older subjects gap narrows with increased hospitalization; they almost catch up with norms.

Hansen, Freesemann, Moodie, and Evans (17)	(N = 40) Documented history of kwaskiorkor	Range: 10–48 mos.	(N = 40) Siblings of experimental Ss matched for age	Experimental: Mean: 11½ yrs. Control: Mean: 11 yrs.	New So. African Individual Scale; Goodenough-Harris drawing test; Intelligence score and drawing score.	Intelligence Score / Drawing Score Exp. 77 / 76 Cont. 78 / 80 Average normal population: 83 (73–93).
Barrera-Moncada (18)	(N = 60) 1. Growth retardation 2. Skin change 3. Edema 4. Psychic changes 5. Hair changes 6. Liver hypertrophy	Range: 15.7–71.0 mos.		60 cases tested 7–12 weeks after hospital admission 75% of cases evaluated 2 yrs. later	Gesell schedules: Developmental Quotients	After 7–12 weeks of hospitalization D.Q. = 65 (expected 100). Marked retardation in language (D.Q. = 50–60). Most improvements in motor development (D.Q. = 74). After two years D.Q. = 61–88.

An important difference to be noted here is the age of hospital admittance of the children with kwashiorkor and marasmus. Many of the children in the nutritional marasmus group studies were six months or younger at the time of admission; however, from all the children included in the studies of kwashiorkor only six children were of similar age at hospital admission. Such a difference in age could have been expected on the basis of previous information on the age at onset of nutritional marasmus and kwashiorkor. It is of special interest in the context of the present report because--as it is discussed later--there might be a significant relationship between the age factor and later impairment.

In contrast to the considerable agreement found among three (11,13,14) of the four studies on children with nutritional marasmus, indicating a prevailing retardation of mental functioning, most of the data from two of the three studies on children with kwashiorkor suggest significant rehabilitation in mental functioning. Cravioto and Robles report that the 20 cases they studied (14), with ages above 15 months at the time of hospital admission, gave evidence of clear improvement to the extent that they functioned almost as well as the norms expected for their age. The remaining six cases who were six months or younger at hospital admittance gave evidence of permanent intellectual damage.

Hansen, Freesemann, Moodie and Evans report that the mean intelligence score of the 40 children they studied, with documented episodes of kwashiorkor nine to 10 years previously, was quite similar to that of 40 siblings of similar age used as controls. While the former had an average intelligence score of 77, the latters' mean was one point higher. The evaluations were done with the New South African Individual Scale which is a test similar in construction to the Wechsler Intelligence Scale for children. The authors noted, however, that the sibling controls were similar in heights and weights to the ex-kwashiorkor patients. Thus, although there is no evidence that the siblings had an episode of kwashiorkor, it is conceivable that their intellectual development might have been affected by a subclinical nutritional deficiency. The possible retarding effect of kwashiorkor in the case of the experimental group was then not detected through such a comparison. However, the authors report that the mean intelligence score of a normal population was 83. Although no statistics are presented to determine whether the difference between the normal and the kwashiorkor and sibling groups was significant, a simple superficial analysis of the magnitude of the difference shows it was quite small indeed. Kwashiorkor, therefore, did not seem to have an irreversible retarding effect.

Anecdotally, it is also worth mentioning that the Mexican and South African studies find corroboration in a previous investigation of similar children. In Uganda, Geber and Dean (19) report mainly through descriptive data that there was considerable improvement in their sample of children. The authors do not report the number of subjects but state that after only a month of hospitalization there were cases that

"no longer appeared to be retarded and compared well with normal African children of the same age." Actually, although other children might not have shown such a marked improvement, the range of scores given for all patients--after a week of hospitalization--for the developmental assessment of the five areas of the Gesell Schedules show that except for the areas of locomotion and language, all cases were scoring above the retarded level for manual ability, adaptive and personal-social behavior.

By contrast, Champakam, Srikantia and Gopalan in India, using tests which assessed selective dimensions of perceptual ability, short-term memory, abstract ability, and incidental and intentional learning, are the only investigators among the ones considered here who reported severe retardation among patients with kwashiorkor. They did find severe deficits in all evaluated areas of cognitive functioning after many years of full nutritional rehabilitation.

Probably differences in sample characteristics, methodological approaches, or even cultural factors could account for the differences obtained in the investigations reviewed in this paper. As previously implied, it is problematic and scientifically risky to categorize these investigations under one heading, analyze the findings and derive conclusions. However, although the data from Champakam, Srikantia and Gopalan might point to the contrary, Cravioto and Robles' data, the report of Hansen, Freesemann, Moodie and Evans, as well as Geber and Dean's descriptive information, suggest that children with kwashiorkor--in contrast to those with severe forms of nutritional marasmus--do not necessarily show later intellectual damage, especially if the children are older than 12 months of age at the onset of the condition.

CONCLUSIONS

The apparent differences in the degree of intellectual retardation that might have existed in the children with nutritional marasmus and kwashiorkor included in the studies reviewed could be partially explained on the basis of the age of onset of the nutritional deficiency. Human and animal data suggest that the younger the organism the greater the possibilities that protein calorie deficiency will adversely affect the growth and maturation of the brain (3). Thus it would appear that there is a greater likelihood that nutritional marasmus compared with kwashiorkor might be more damaging to the brain since generally its onset occurs when the gross weight of the brain is increasing at a faster pace than at any other postnatal developmental stage.

However, according to the previous analysis of the data on the marasmic subjects even infants older than 12 months at the time of the hospitalization were severly impaired after months of nutritional rehabilitation. Thus, it appears that if the onset of the nutritional defect in these subjects occurred at about the first year of age, other factors

should also be taken into consideration in interpreting the differences in the possible intellectual deficits that might be observed between marasmic and kwashiorkor subjects. One of these factors seems to be the nature of the conditions. Marasmus, contrasted with kwashiorkor, is more likely to result from the action of various adverse biosocial factors associated with poor diet. Also, marasmus does not generally follow a clear timetable with a distinct beginning, but is likely to develop gradually, perhaps from birth on, increasingly debilitating the child and limiting his possibilities of responding to his surroundings. Kwashiorkor, on the other hand, is a much clearer clinical entity, more likely to have a single dietary origin; also it often follows a timetable after prolonged weaning and the substitution of starchy diets for mother's milk. Thus, the differences in the original conditions might explain some of the differences in the degree of retardation between the children with marasmus and kwashiorkor. The marasmic child is more likely to be impaired because he has greater probabilities of having been exposed for a longer period of time to poor diet as well as to multiple adverse biosocial factors. By contrast, the child who undergoes a severe protein deficiency at a specific period in time, after having had an otherwise healthy development, seems to have a better likelihood of recovering his intellectual potential.

The need to consider the length of the nutritional deficiency and the related psychosocial factors in interpreting the intellectual deficit of malnourished children is supported by the findings of a careful and detailed study published by Chase and Martin (22). They studied 19 American children admitted to the hospital "at less than one year of age with the primary diagnosis of generalized undernutrition." On the basis of social and medical histories, undernutrition was assumed to have been present from birth to the time of admission. The sample was divided into 9 cases who received treatment before, and 10 cases who received treatment after, age 4 months. Developmental assessments were made of all 19 children after a mean of three and a half years following admission to the hospital. The results of the assessment showed that children with undernutrition lasting longer than the first four months of life were significantly more impaired than those whose condition and hospitalization occurred before the age of four months.

Although, as suggested by Chase and Martin, undernutrition in the United States is different in many respects from undernutrition in many underdeveloped countries, their findings suggest that the length of the nutritional deficiency is a variable of primary importance in the probabilities for intellectual recovery. Finally, there are reasons to believe that the learning ability of a child severely malnourished for a prolonged period or during the first months of life is likely to be seriously affected. No behavioral evidence exists, however, to suggest that this impairment is solely or predominantly affected by the specific deficiency in proteins and calories. There are many reasons to assume that the

impairment is the result of an overall state of biological and psychological deprivation.

NOTE: Dr. Ernesto Pollitt was assistant professor of psychology at the Child Study Center and Department of Pediatrics, Yale University School of Medicine at the time of the Conference. Currently he is at the United Nations Research Institute for Social Development, Geneva, Switzerland. This study was supported by a grant from the Children's Bureau, DHEW.

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IV

Field Studies of Malnutrition and Child Development

The Ecologic Approach: The Mexico Study
Joaquín Cravioto

The Intervention Approach: The Guatemala Study
Cipriano A. Canosa, João B. Salomon, and Robert E. Klein

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THE ECOLOGIC APPROACH TO THE STUDY OF NUTRITION AND MENTAL DEVELOPMENT: THE MEXICO STUDY

Joaquín Cravioto
Hospital Infantil de México

Study of the relation between nutrition and mental development is particularly complex because of the influence of environment on mental development and the interrelations between nutrition and culture. The ecologic approach seeks to determine the relative importance of specific variables and their interactions with other factors by means of detailed studies of a single population over time. Our study is based on the hypothesis that intellectual growth at all stages and performance at school age are related to nutrition and health at a much earlier age. We have chosen to study all the infants born during one calendar year in a single Mexican village; these children are to be followed for seven years. The children and their families yield information concerning their dietary, medical, socioeconomic and developmental status. By studying the children from their prenatal period to their seventh year, the earliest age amenable to crucial psychometric tests, we can analyze the influence of social, economic and familial circumstances on changing nutritional status; the effect of malnutrition on physical growth and behavioral development; and the interaction of nutrition with disease.

INTERPRETATION OF NUTRITIONAL STATUS

Nutrition is more than the adequacy of the food consumed and the physical state of the individual. Operationally, foods and feeding have at

least three dimensions. The physiologic dimension utilizes nutrients as the unit of measure, recognizing that nutrients provide chemical substances for growth, for body maintenance, and for regulation of metabolism. The second dimension of foods may be termed psychophysical, and has as its unit of measure the stimulation that food evokes through texture, consistency, color, aroma, flavor, temperature, and other properties. The same food prepared differently might contain the same nutrient value but appear different and have a different acceptance. The third or psychosocial dimension centers around mealtime and the opportunities for symbol formation. The value of a food may derive from its use as a reward or punishment, its linkage to a gratifying or non-gratifying person, and its specific importance within the ethnic or social group. Mealtime also provides opportunities to establish role and status within the family, e.g., who is served first, and in the community, aiding the child in the processes of socialization and acculturation.

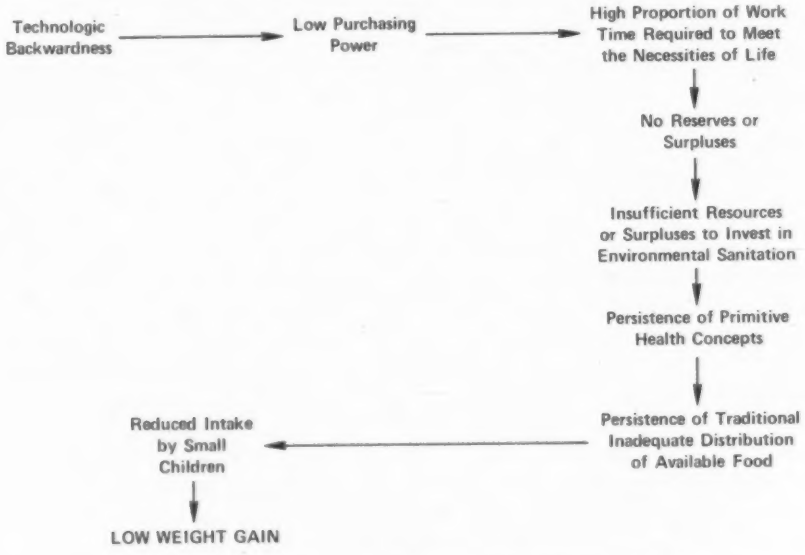
Technologic Backwardness
Low Purchasing Power
High Proportion of Work Time Required to Meet the Necessities of Life
No Reserves or Surpluses
Insufficient Resources or Surpluses to Invest in Environmental Sanitation
Persistence of Primitive Health Concepts
Persistence of Traditional Inadequate Distribution of Available Food
Reduced Intake by Small Children
LOW WEIGHT GAIN

Figure 1: The interrelation among biosocial factors and low weight gain.

THE RELATION OF BIOLOGIC AND SOCIAL FACTORS IN MALNUTRITION

If low weight gain is used as the single most characteristic sign of protein-calorie malnutrition in infancy and early childhood, it is relatively easy to demonstrate the ecologic nature of malnutrition. Some of the interrelations among biological and social factors leading to low weight gain are illustrated in a series of flow charts based on data obtained

from our study of several communities in Mexico, Central America, South America, and Africa (1-4). Figure 1 depicts a society where systematic application of modern technology is minimal or absent, resulting in low income and purchasing power for a portion of the population. Since the total community income is barely enough to cover the minimal necessities of life, lack of surplus or reserves limits investment in environmental sanitation. The resultant diarrhea and related diseases perpetuate traditional concepts about the role of food in the production of disease, e.g., that milk and other foods cause diarrhea in infants. Such conceptions determine the pattern of distribution of food within the family, resulting in a net reduction of the more nutritious foods fed to the infant. Therefore, low weight gain or malnutrition results.

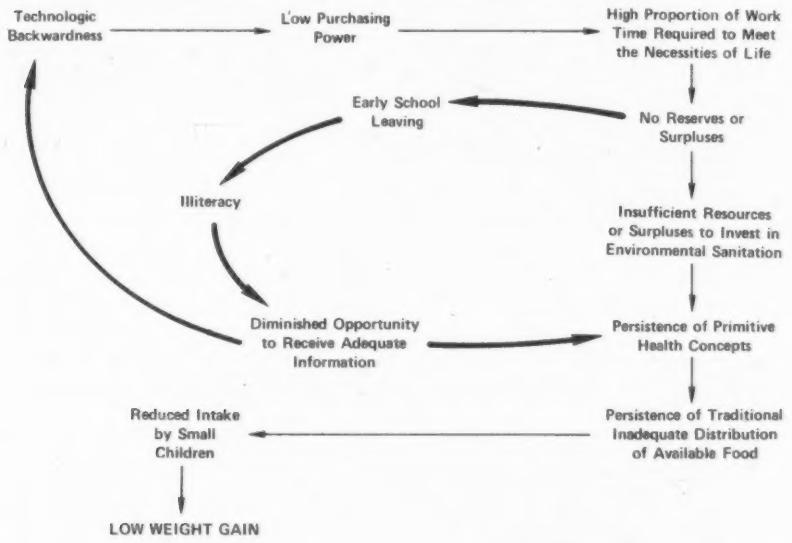
Technologic Backwardness
Low Purchasing Power
High Proportion of Work Time Required to Meet the Necessities of Life
Early School Leaving
No Reserves or Surpluses
Illiteracy
Insufficient Resources or Surpluses to Invest in Environmental Sanitation
Diminished Opportunity to Receive Adequate Information
Persistence of Primitive Health Concepts
Reduced Intake by Small Children
Persistence of Traditional Inadequate Distribution of Available Food
LOW WEIGHT GAIN

Figure 2: The interrelation among biosocial factors and low weight gain.

A second pathway (Fig. 2) starts with inadequate family income, leading to pressures for children to drop out of school to increase the purchasing power of the family unit. This in turn results in illiteracy and diminished opportunity to benefit from new information in the future. This pattern establishes a feedback mechanism for technologic backwardness and persistence of primitive concepts of health and disease. Alternatively (Fig. 3), individuals leaving school early assume adult social roles at an earlier age than had they remained students. This increases the possibility of early marriage, probably to an equally uneducated mate, therefore multiplying the risks for inadequate child care, illness, and malnutrition.

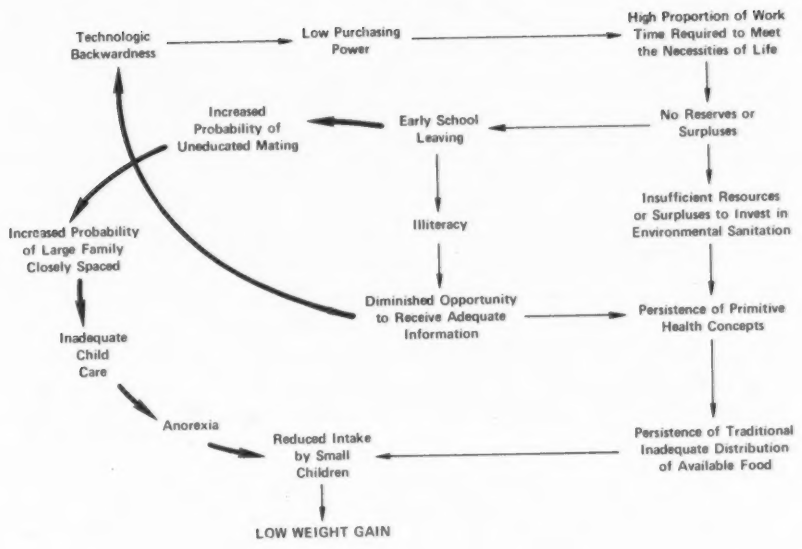
Technologic Backwardness
Low Purchasing Power
High Proportion of Work Time Required to Meet the Necessities of Life
Increased Probability of Uneducated Mating
Early School Leaving
No Reserves or Surpluses
Increased Probability of Large Family Closely Spaced
Illiteracy
Insufficient Resources or Surpluses to Invest in Environmental Sanitation
Diminished Opportunity to Receive Adequate Information
Persistence of Primitive Health Concepts
Inadequate Child Care
Anorexia
Reduced Intake by Small Children
Persistence of Traditional Inadequate Distribution of Available Food
LOW WEIGHT GAIN

Figure 3: The interrelation among biosocial factors and low weight gain.

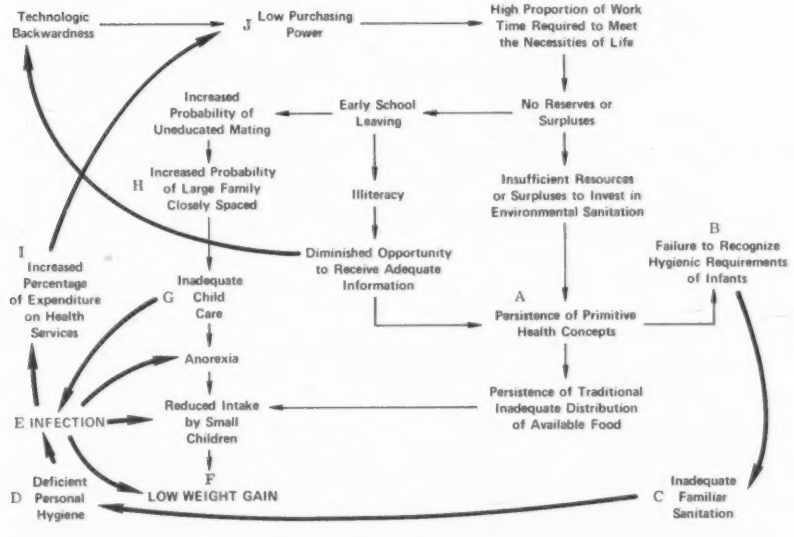
Technologic Backwardness
J Low Purchasing Power
High Proportion of Work Time Required to Meet the Necessities of Life
Increased Probability of Uneducated Mating
Early School Leaving
No Reserves or Surpluses
H Increased Probability of Large Family Closely Spaced
Illiteracy
Insufficient Resources or Surpluses to Invest in Environmental Sanitation
B Failure to Recognize Hygienic Requirements of Infants
I Increased Percentage of Expenditure on Health Services
Diminished Opportunity to Receive Adequate Information
G Inadequate Child Care
A Persistence of Primitive Health Concepts
Anorexia
E INFECTION
Reduced Intake by Small Children
Persistence of Traditional Inadequate Distribution of Available Food
F LOW WEIGHT GAIN
D Deficient Personal Hygiene
C Familiar Inadequate Sanitation

Figure 4: The interrelation among biosocial factors and low weight gain.

Another pathway (Fig. 4) has at least two different initiating factors. The first is at the level of the persistence of primitive beliefs of health and disease (A), producing insufficient awareness of the hygienic needs of the infant (B), leading to a chain of unsanitary conditions in the community and home (C) including those of the mother (D) and to a higher incidence of infections in the infant (E) directly or indirectly producing malnutrition (F). Another pathway is that between inadequate child care (G) and the poor personal hygiene cycle just described. Increased morbidity (H) increases spending on health services (I) and further decreases purchasing power (J).

It is apparent that malnutrition is associated with a host of social and biological variables, many of which are alone capable of significantly influencing physical and mental development of children either directly, to the degree they can modify growth and differentiation of the central nervous system, and/or indirectly, by affecting the opportunities for obtaining and profiting from experiences.

NEURAL DEVELOPMENT IN MALNUTRITION

The problem of isolating the effects of malnutrition on mental development is complicated by the varying vulnerability of the central nervous system to insult at different ages. Dobbing (5), Davison and Dobbing (6), and Benton and co-workers (7) have reported species differences in the age of most rapid development of the central nervous system, both in structure and in composition. In each species, the impact of malnutrition depends on the timing of the insult in terms of the period of most rapid growth and differentiation. Therefore, not only the type and degree of malnutrition but also the time of its occurrence must be considered if the relationship between exposure and outcome is to be assessed.

Time is related to the problem of malnutrition and development in another important way. Generally, where human malnutrition prevails, greatest nutritional stress extends from the period of weaning through the preschool years. Children who survive develop a pattern of eating that increasingly permits continued survival and growth. Nutritional status, though suboptimal, is no longer as severely depressed as it was earlier. Assessment of the developmental consequences of malnutrition experienced during infancy and the preschool years rarely can be fully evaluated at the time of the insult, particularly the evaluation of the consequences of malnutrition as related to functions such as intellectual ability, school achievement, and eventually, social and economic competence. For their assessment, a considerable lag must occur between the period of primary risk and the period in which the functions are measurable. During this lag period, many other environmental factors may influence the child's developing competence. To assess the effect of the nutritional variable, it is essential to understand and interpret the

influence of these social, medical, and other variables on the developmental course during the intervening period.

The time lag just described is important in itself. Clearly, the effect of malnutrition on the developing nervous system is unlikely, except rarely, to manifest itself fully by changes in simple reflex and adaptive behaviors. Lashley (8) in 1929 demonstrated that as little as three percent of destroyed tissue in the rat brain affected more complex learning performances. Therefore, lags in developmental differentiation or the effects of lesions produced in the nervous system by malnutrition would be expected to manifest themselves in varying ways at varying times after the primary insult. At older ages, when more complex demands for integration are made, opportunities exist for increased sensitivity in the assessment of the consequences. A time gap is essential if the complete extent of the insult is to be measured.

THE STUDY COHORT

Geographical Characteristics

To examine the complex set of variables outlined above, it was necessary to study a large group of children. We estimated we would need a community large enough to provide about 250 births in the annual cohort to be studied longitudinally. The community selected also had to contain a considerable range of variation in social conditions and nutritional status, as well as a willingness to cooperate, i.e., enroll and remain in the study. Since the project is longitudinal, it was essential that the population be relatively stable and that a high proportion of the families and infants enrolled for study at birth be likely to remain in the community for the duration of the study.

During the past 10 years, our team has conducted a series of cross-sectional studies in the village chosen for this study. These have shown a high level of population stability, excellent cooperation, a wide range of variation in social, economic, familial, and health attributes, and an annual birth expectancy of 300.

This semitropical village has a central shaded plaza from which a series of unpaved streets radiate to form roughly quadrangular blocks; these permit ready access to the central clinic for the project.

Sugar cane consitutes the major commerical crop in the surrounding agricultural area. A small amount of cotton and rice is also grown commercially. Interspersed among the large commercially organized fields are small family parcels used by the villagers for growing corn, chilies, tomatoes, other garden crops and fruits for their own consumption.

Census Data

In 1965, there were 5,637 people 0-85 years of age in the 1,041 village families. There were approximately equal numbers of men and

women of all ages. The population was relatively young, with 50% of the individuals under 15 years old and 80% under 35. These age ratios reflect the reduced life expectancy so typical of developing regions of the world.

Vital statistics prior to 1934 were considered unreliable because of the upheaval and poor reporting during the Agrarian Mexican Revolution. Therefore, our projections of births and deaths were derived from data from 1934-1965. The number of live births in the village had markedly increased during 1960-1965. In contrast, the infant mortality rate (under one year of age per 1,000 live births) had slightly decreased. Using the data reported for 1961-1965, 334 live births were predicted in 1966; 22 deaths were expected before the cohort of newborns would complete their first year of life, and eight more deaths between the first and fifth year of life. Accordingly, the number of survivors at the end of the five years of study was estimated to be around 304.

Economic Characteristics

The principle occupation of the villagers is farming (64.8%), with relatively few people employed as workers and artisans (12.4%). A still smaller number engage in commerce or practice a profession (9.3%).

The social and economic status of people who do farm work is by no means homogeneous. The distribution of the different levels of agricultural workers shows that the preponderance (69.2%) of people are employed seasonally as day laborers and make only a marginal wage. They supplement their income by the seasonal planting of individual food crops on communal lands some distance from the village. Day laborers generally are not insured for social and health services and represent the most economically deprived segment of the population. About 23% of the group engaged in agriculture have family plots they cultivate both for small scale commerce and their own use. Owners of small farms or renters of relatively high grade farm lands earn the highest income. Together these two groups constitute about seven percent of those engaged directly in agriculture as the main source of family income.

Until about 1940, the village was almost entirely agricultural. Since then, it has undergone a transition to a more mixed economy, representing more advanced levels of both industrial technology and agricultural organization. Shortly after 1940, a large cooperative of sugar cane growers and a sugar refinery were established. Much of the surrounding land was assimilated into the large cooperative. Twenty years later a mattress factory employing 20 workers was established, followed five years later by the construction and operation of a small cotton gin (10).

These changes in the economic base have been accompanied by increases in availability of transportation, improvement and construction of roads, and a considerable increase in the amount of contact between people in the village and those in urban and semi-urban centers. The

technologic advances have been accompanied by the improvement of a variety of village services, including schools, a central water supply, and a social welfare and health center. The village now has one kindergarten, two primary schools and one school accepting pupils from the seventh to the ninth grade. Attendance at school is compulsory from age seven through age 12 years. Schooling beyond this age is elective.

Health Status of the Study Cohort

Health conditions in the community and the opportunities available for growth and development of children vary greatly. Considerable range in growth exists among the village children, with coefficients of variation at each age of approximately 10% for weight and 5% for height. A comparison of growth attainment of these children with that obtained for a sample of the earlier school generation in the same village suggests that the technologic changes have not effected a change in either mean height or weight for age, and shows no diminution in the variability of these characteristics in the population (Fig. 5).

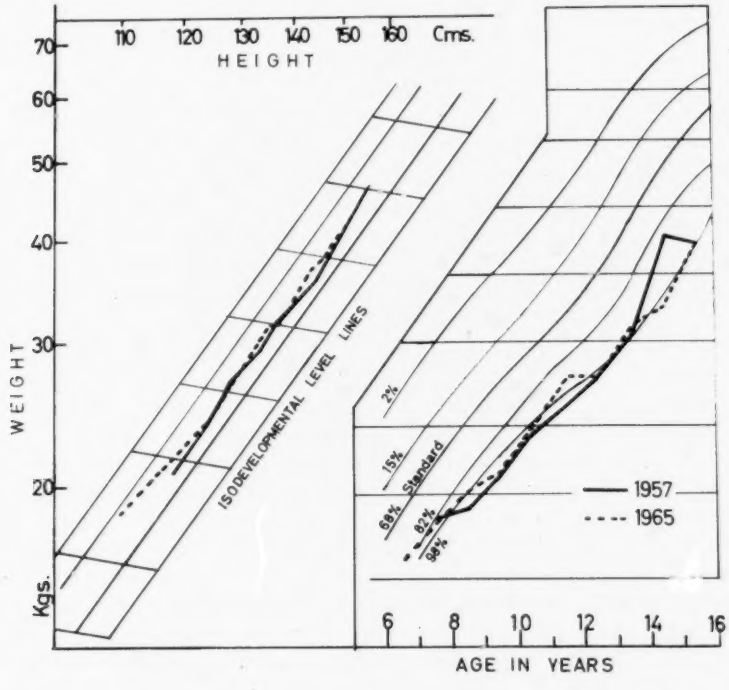

Figure 5: The relation between height and weight in two generations of school children.

The second set of data uses tuberculin reactivity as an index of health risk in children. It reflects a high frequency of exposure to sources of infection, with age-specific values for positive reactions to tuberculin showing a continuing rise of positive reactors with age.

Another measure for assessing the suitability of the village for our study was a clinical evaluation of the prevalence of malnutrition in a sample of households with preschool children. These data indicate that at all preschool age levels, mild to moderate and severe degrees of malnutrition were present in the community in such high frequencies that it was representative of communities with chronic undernutrition (Table 1).

TABLE 1

Prevalence Rates of Malnutrition as Judged by Weight for Age in a Sample of Preschool Children

Age in months	Number of children	% Malnutrition		Normal %
		Third degree	Mild-moderate	
0– 5	132	0	5	95
6–11	112	3	9	88
12–23	210	5	18	77
24–35	207	9	21	70
36–47	212	8	8	84
48–59	201	5	11	84

All of the data above provided the basis for selecting this particular community as a suitable site for the longitudinal study of the ecology of growth and development of children.

THE MAJOR VARIABLES

Nutrition

Several main variables are being studied. The first group consists of those involved with nutrition, a dependent variable, which includes: patterns of infant feeding; patterns of family feeding; and maternal attitudes and concepts towards food and feeding, particularly regarding infancy and childhood in both health and illness. These variables have been investigated through dietary surveys of each household, observing the meals, and by weighing and recording the distribution of various foods within the family. Additional information concerning attitudes towards infant and child feeding in health and disease has been obtained by questionnaires, by a series of intensive interviews of the same people over time, and by continuous observations of practices relating to feeding and the introduction of new foods.

Quantitative, as well as qualitative, data have been collected at short intervals, making possible the collection of a full record of the types and quantities of food eaten by children, except for breast milk. However, after three or four years of age the snacks eaten outside the home are missed by the investigators.

The short intervals between data collection should make it possible to analyze in detail the probable interactions between the dietary and other variables. Estimates of the total intake of calories and nutrients are subject to the same limitations of any quantitative food consumption survey in terms of their physiological interpretation.

Physical Growth

The measures of physical growth are regarded here as both dependent and independent variables: dependent because growth is influenced by factors such as dietary intake and morbidity, and independent because physical growth, as such, is one indication of nutritional status. Our battery of standardized anthropometric measurements includes body weight, total body length, head circumference, chest circumference, arm circumference, and skinfold thickness. Growth is measured at short intervals to examine closely the interaction between variables such as illness and weight change.

Morbidity, Mortality, and Health Status

Records of morbidity and mortality are continously maintained. These are based on routine biweekly pediatric examinations and an interim history from the mother as well as on close observation of sick children in the intervening time periods. These records include an assessment of the severity of the illness, its duration, family methods of treatment, response to treatment, and the presence or absence of concurrent or antecedent illness in all family members. Laboratory methods are used to aid the diagnosis and treatment of illness but are not a regular part of the research study. We think that such methods, especially those dependent on blood samples, prejudice cooperation by the families.

Demographic Variables

Family variables under study include: definition of the family's economic position; family structure and size; ordinal position of all children; maternal and paternal age; family health characteristics; nature of housing and sanitary facilities; parental education; degree of parental contact with sources of information in the broader culture; familial attitudes towards health and disease, especially regarding cause and treatment of illness; maternal proclivity towards change; and mother's psychological profile.

Psychological Variables

Behavioral development is being assessed at all ages using well-established test methods, general observations, and parental interview. In the first three years of life, intellectual level has been assessed monthly by Gesell's preschool developmental examination and by clinical findings of behavioral disturbances. The pattern of child care and types of stimulation of the child at home are recorded at short intervals in an attempt to indentify those aspects of child care that may influence the child's behavioral development or mediate the influence of nutritional and morbidity variables. Behavioral development beyond age three will be assessed by intelligence tests appropriate to the child's age, including special examinations of intersensory development, perceptual motor competence, language development, concept formation, styles of response to cognitive demands, and strategies for learning. In school the child's learning readiness, as well as his achievements and level of social competence, will be evaluated.

DEPENDENT VERSUS INDEPENDENT VARIABLES

The set of variables just listed comprises both dependent and independent variables. Among the independent, two types can be identified. The first involves measures which purport to assess attributes that are not expected to show much change on the basis of previous experience. These include assessments of maternal attitudes toward child rearing, demographic data about the family which are revised as family conditions change, an index of social position within the community, concepts of health and disease, and the cultural background of the parents and grandparents. These relatively stable variables are assessed regularly but relatively infrequently. The second type of independent variable consists of measures expected to change with time, and thus must be repeatedly collected with the interval changing as a function of the child's age. Included among these are questionnaires or scales or both concerned with home sanitary conditions, personal hygiene of parents and siblings, pattern of child care in the home, and detailed observations of maternal behavior and mother-child interaction during the psychological test sessions.

Physical, mental, and behavioral development are the dependent variables. In the present program, these are outcome measures that will be related to one another and each considered against the background of nutrition, health, and social environment that has characterized the child.

Reliability and Standardization of Measures

The reliability of all measures and ratings has been periodically assessed. Any measures with excessive intra- and inter-examiner or score-rescore error levels were either modified or eliminated. For

anthropometric measurements, including weight and height, instruments are regularly recalibrated and examined. Errors beyond the two percent level are considered excessive. For rating scales, reliability levels expressed as retest and/or rescore correlation coefficients of less than 0.82 are considered unacceptable.

Training has involved the use of team members--a trainer and trainee--to collect data in pairs, with one member already competent in administering the instrument and able to demonstrate to the trainee, who observes and scores the results. Training of new staff is done with infants not belonging to the cohort.

Restandardization of techniques is done at regular intervals. In a longitudinal study the standardization of data collection is a continuous process, but it is also important not to overload the children and families with more measurements and interviews than planned in the research design. We have found that a useful way of solving these two apparently conflicting needs is to study all children born the month prior to the actual date of the research cohort. In this way, a group of 20 infants one month older than the oldest member in the cohort is available for improving instruments and procedures.

PRELIMINARY RESULTS

Socioeconomic Status

The study cohort consists of all children born in the village during the 12-month period from March 1966 through February 1967. All pregnant women due to give birth during this period were identified and registered for the study. No refusals to participate occurred. Three hundred children born in the village were included in the study. In addition, five children, who for various reasons had been born elsewhere but who came to live in the village during the first three months of life, were included in the group for longitudinal study.

An equal number of boys and girls were born during the 12-month intake period. Their social backgrounds closely paralleled the distribution of the adults in the village as a whole. Minor differences from the overall distribution resulted wholly from the constriction in age range associated with reproductivity. The great majority of families were involved in agriculture, with 66% of all children born to such families. Sixteen percent of the children were born to families of workers and artisans. Equal numbers of tradesmen and professional families were represented in the 4.6% of the births to these social groups. Some 13% of the births occurred in families in which it was difficult or impossible to define an income source. These families were ones in which the mother and infant depended mainly on other familial or social sources of support.

Infant Mortality

Of the 300 children delivered, 296 were alive at birth and four were stillborn. Of the infants born alive, seven died during the first week of

life and three during the remainder of the first month. Combining the stillborns and those who died during the first week, the perinatal death rate was 11/300 or 35.6/1,000. If all deaths of liveborn infants during the first month were combined, a neonatal death rate of 33.6/1,000 was obtained. Unfortunately, because of custom, those stillborn or who died within a few hours after birth were not weighed. Of the remaining seven infants who died during the first month, five had birth weights below 2,300 gms. More girls than boys were stillborn or died early. Frequency of stillbirths or neonatal deaths was not related to any particular category of occupations. Martial status was also unrelated to the stillborn and infant mortality; all occurred in families having both parents.

The stillborn and mortality rates in this cohort are relatively low compared with many of the rates reported in Africa and India. The rate of about 10/1,000 is lower than the rates of approximately 30/100 reported by Gordon and his colleagues for the Punjab (11,12), Gamble for Sierra Leone (13), and Hauck for Lagos, Nigeria (14). The rate in our village, however, is more than twice that reported for an advanced industrial city such as Aberdeen, Scotland (15). The death rate of liveborn infants during the first week of life was almost identical in our village to that of Sierra Leone and Lagos. The total infant death rate of 33.6/1,000 compares favorably with that of 60/1,000 for Sierra Leone and 73.5/1,000 for the 11 Punjab villages studied by Gordon and his associates, and is very similar to that of Lagos, which is approximately 30/1,000.

A striking seasonal pattern appeared to characterize the stillbirth and neonatal deaths, with eight of these occurring in the first three months of the year and nine of the total 13 occurring in the first half of the year. Analysis of the stillborn and neonatal deaths for the preceeding five-year period confirmed the seasonal trend.

Birth Weights

The mean birth weight in the cohort was 2,898±444 gms; 12.4% of the cohort had birth weights less than 2,500 gms with only 7.6% of the infants weighing over 3,500 gms at birth. As expected from other data, the mean birth weight of boys was significantly higher ($P>0.02$) than for girls; 2,977±394 gms for boys and 2,860±408 gms for girls. The mean birth weight of these infants was markedly lower than that of Swedish and North American infants, for whom mean birth weights of 3,400 gms have been reported (16), and closely resembled that of Indian infants in Delhi, Negro infants in the French Sudan, and Indian infants in Singapore (17).

The median body length was 48.5 cms, with 25% of the children measuring less than 47 cms and an equal number measuring between 49.5 and 53.0 cms. Like birth weight, mean body length at birth was significantly higher for boys than girls. Boys had a mean length of 48.7±1.8 cms and girls 48.0±2.0 cms. This difference, though small, was statistically significant.

Biologic and Cultural Characteristics of the Mothers

The age distribution of mothers in the cohort spanned 30 years with two giving birth for the first time at age 13 and with the oldest mother giving birth at 43 years. The mean age of the mothers was 25.6±6.8 years. The median age was 24 years, with 75% of mothers younger than 30 years.

The heights and weights of the mothers also varied widely; the heights ranged from 133 to 165 cms, with a mean value of 148.2±2.8 cms. Weights of the mothers ranged from 32 to 86 kgs, However the upper weight value was markedly atypical. Mean weight was 53.0±4.8 kgs, with a median value of 51 kgs, suggesting a slight excess in frequencies at the lower end of the distribution.

The numbers of pregnancies in the cohort ranged from 1 to 16. Relatively equal numbers of births occurred to women having up to four pregnancies and decreased after the fourth pregnancy. From an epidemiologic standpoint (18), the distribution of parities according to their mean value is not useful. Available evidence suggests that special conditions of risk attend first births and those occurring after the fifth pregnancy. Sufficient numbers of cases exist in each of these parity ranges to permit analysis within the cohort.

In addition to the biological characteristics of the mother, at least three other maternal characteristics were useful to consider: personal hygiene; literacy and education level; and contact with mass media information. Wide variation in personal cleanliness existed among the mothers, and subgroups differing in degree of adequacy of personal hygiene could readily be defined. Ratings of personal hygiene ranged from a low of 20% to a high of 100% in the cohort mothers. The median percentage score for personal hygiene was 56.5, with 75% of the mothers scoring below an estimated cleanliness level of 76%.

Assessment of literacy and school attainment of the mother showed that almost one-half were completely illiterate. Another 10% had become literate through exposure to adult literacy campaigns or they had acquired basic literacy by completing one school grade. Only 6.4% had completed the full primary school curriculum of six years, and only 1.5% had schooling beyond primary school. From a functional point of view, it appears potentially useful to group the mothers into four classes: illiterate; adult literates who had completed first and second grade; those who completed the third through fifth grades; and those who completed primary school.

Very few of the women watched television. One-half had little or no regular contact with radio and almost 70% did not read newspapers except occasionally. If the calculation of newspaper readers is limited only to the literate population, the percentage of those who can and do read them is slightly below 50%.

Considerable variation existed in size of household, ranging from a single-child family of three individuals to both nuclear and extended

amilies with a dozen or more members. The sanitary structure of the household also varied greatly, with the rating expressed as a cumulated percentage score based on the assessment of objective conditions and facilities for sanitation. Most households were substandard, but a considerable number exhibited good to excellent conditions and facilities. Sufficient variation exists to permit the sanitary structure of the household to be related as a differential background factor to the characteristics of the child. No data on behavioral development are yet available.

SUMMARY

In this longterm ecologic study we will attempt to clarify the relation of physical and mental growth to nutrition in a cohort of the total live infants born during a calendar year. This group lives in a community in transition from an agricultural to an industrial economy. We intend to assess the mental development of the infants from birth to the beginning of their school years and identify different patterns of achievement and rates of development.

Attitudes towards food and patterns of eating will be described for the children and their families, and the natural history of protein-calorie malnutrition will be recorded. We also plan to analyze numerous socioeconomic, medical and anthrometric measures and evaluate the usefulness of special techniques such as the Guttman sociometric scales. We plan to develop other sociological methods to identify and quantify the interrelations among the major classes of variables influencing nutrition, illness, and mental performance.

Analysis will be made of the social environment in which early learning occurs; the biologic, social and nutritional correlates of physical and mental development; and the biologic, social and nutritional correlates of health and illness of these children during their first seven years of life. In addition, we will study the influence of varying degrees of malnutrition occurring at different periods on the subsequent mental development in children. Also important are the patterns of mothering, their effects on nutritional practices, disease prevention and treatment, and growth and development.

In the course of reporting these findings, we anticipate numerous opportunities to consider the problems of assessing nutritional status, severity of disease, measures of physical development and mental growth. Consequently, we expect to contribute to the development of methodology for the complex task of field study of nutrition and intelligence.

NOTE: This study was supported by grants from the Association for the Aid of Crippled Children, The Nutrition Foundation, Inc., and the Hospital Infantil de Mexico. During its initial stages contributions were also received from the Williams-Waterman Fund for the Combat of Dietary Disease, the Gerber Baby Fund, and the Cooperativa Emiliano Zapata, of Zacatepec, Mexico.

452-750 OL - 72 - 13

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THE INTERVENTION APPROACH: THE GUATEMALA STUDY

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The staff of the Human Development Division of the Institute of Nutrition of Central America and Panama (INCAP) has been engaged during the past several years in a field program to study the effects of malnutrition on physical growth and mental development. The goal of this long-term prospective study is an integrative analysis of the nutritional and socioculutural factors affecting mental and physical development, i.e., to determine the effects of malnutrition, per se, as they interact with other variables that affect early child development. To achieve this, the project is concerned with the study of physiological and social characteristics of all preschool children and their families in four villages while providing two of the villages with nutritional supplements and all of the villages with medical care and social stimulation.

Extensive research on animals by other investigators has shown that various degrees of malnutrition disrupt physical and mental maturation, including bone growth (1), biochemical maturation (2), development of the central nervous system (3,4), and behavior and learning ability (5,6). Studies of the mental development of children in Mexico (7,8), in Africa (9), and in other parts of the world (10-12) suggest that protein-calorie malnutrition may be accompanied by altered behavioral and personality patterns.

The human studies have been primarily concerned with the effects of severe malnutrition on mental development. Little information exists on the effects of long-term mild or moderate forms of protein-calorie

malnutrition which affect even larger proportions of the children in developing countries. In interpreting human studies, it must be recognized that populations with malnutrition also may suffer a variety of sociocultural and educational deprivations which in turn affect mental development. Under these conditions, the roles of nutritional, as opposed to sociocultural, factors in mental development may be extremely difficult to separate and assess.

The ideal investigation for testing the hypothesis that malnutrition lowers mental ability would cover the entire adaptive cycle from conception to adulthood. However, for practical administrative, technical, and professional reasons, our project has been limited to the study of all pregnant women, infants, and preschool children to age seven years in each of the four villages. While serious and possibly irreversible physical damage caused by postnatal undernutrition may be clearly apparent during the first five years of life, impaired mental development may not be demonstrable until a later age. Therefore, an especially important period to study for evidence of the physical effects of malnutrition is that from birth to five years, whereas the possible effects of malnutrition on mental development are most readily demonstrable from four years on. Consequently, any study intended to demonstrate the significance of malnutrition as a factor in impaired mental development must extend over sufficient time to permit quantitative evaluation of both the malnutrition incurred and the level of intellectual ability achieved. A project restricted to seven years limits the possibility of determining fully the effects of early protein-calorie malnutrition on adolescent or adult mental development. However, the results of this study may indicate the need for a longer period of continuous investigation or for a return for reevaluation of the children at one or more later dates.

IDENTIFICATION OF THE VARIABLES

Our first task was to identify the most relevant and important variables involved in the hypothesis that protein-calorie malnutrition affects mental and physical development. Three independent variables were defined: state of nutrition, sociocultural environment, and medical care. Mental development was identified as the dependent variable. A major difficulty arose in developing methods applicable under field conditions. Available methods used under modern clinical and laboratory conditions often could not be used in field situations. To test the validity and reliability of the instruments we developed during the three years of preliminary studies, all methodology was tested under conditions similar to those anticipated for the definitive study.

State of Nutrition

The state of nutrition of a population is commonly defined by food production, distribution, availability, consumption, and utilization of

nutrients. For the individual, the state of nutrition is assessed by medical and dietary history, clinical examination that includes anthropometric measurements, radiographic studies of bone development, and biochemical and hematologic tests.

After extensive testing we developed methods adequate to define malnutrition within the populations to be studied. These methods included seven anthropometric measurements, hand-wrist radiographs, determination of morbidity patterns, and dietary surveys. All methods were found applicable to preschool age children and were incorporated into our standard operating procedure.

Sociocultural Environment

During the preliminary study we found it necessary to collect information about a wide range of variables to determine those most likely to affect mental development. Information was obtained concerning family composition, community relationships, social status, migration, patterns of communication with the wider world, and factors concerning economic status. Social class scales were developed to determine the status of all families in a village, and family expectation scales were designed for specific age groups.

Medical Care

A thorough knowledge of morbidity in our area of rural Guatemala was necessary to provide adequate medical care. Our assessment of morbidity included study of the specific diseases and injuries most often encountered, the frequency, duration, and severity of disability, and their potential for causing death.

Mental Development

A number of problems were encountered in developing tests of mental development. First of all, the existent tests for intellective function had been developed under the conditions found in the more developed countries; these were not directly applicable to the conditions found in the Guatemalan highlands. There also was a problem of which approach to testing should be taken: developmental scales, standard IQ tests, or tests of specific intellective functions (13). A major difficulty was the lack of a continuous procedure applicable at each successive age.

Two sets of tests were developed to measure mental performance: the Composite Infant Scale which utilizes a selection of items from the Bayley, Cattel, Gesell and Merrill-Palmer Scales to measure development at 6, 15, and 24 months of age; and the Preschool Battery, which explores four areas of intellectual development--perception, learning, memory, and language--and other behavioral characteristics such as attention, motivation, persistence, resistance to distraction and ability to inhibit impulsive motor responses. Four criteria determined the choice

of tests in the Preschool Battery for children aged three to seven years: 1. they should be culturally appropriate; 2. they should require simple, and when possible, non-verbal responses; 3. they should be game-like to promote interest and participation; and 4. they should measure cognitive processes.

Taken together the Composite Infant Scale and the test of the Preschool Battery may be used to measure mental performance from five months through seven years. Furthermore, several of the tests have discriminated satisfactorily between well- and poorly-nourished children in rural Guatemala.

RESULTS FROM PRELIMINARY STUDIES

Preliminary data indicate that protein-calorie malnutrition has an impact on children even earlier than was thought. The results suggest a complex interrelationship between maternal health and nutritional status and fetal development, as well as between nutrition and infant or child development. Suggestions of a correlation between early malnutrition and mental development have also been obtained. Below are some of the preliminary results.

Mental Performance After Malnutrition

The primary goal of determining the effects on mental development in children who have undergone malnutrition was approached in two studies on 5- and 6-year-olds recruited from a nutritional rehabilitation day care center in rural Guatemala (14). Twenty children were selected who had recovered from second or third degree malnutrition and all were 10% or more below their expected height for chronological age; their mean age was 67.6 months. The control group consisted of 10 well-nourished children who had had no history of serious malnutrition and who showed less than a 10% deficit in height for chronological age; their mean age was 64.4 months. The control group was selected from siblings of children who had attended the rehabilitation center during the previous year. The two groups were also matched for father's occupation, parental education, living conditions, and family structure.

In the first study, the control group performed significantly better than the previously malnourished group in four of the six mental performance tests, namely memory for sentences, memory for digits, memory for incidental learning, and memory for intentional learning. The results of the other tests, matching familiar figures and haptic-visual matching (touching a planometric geometric stimulus while looking for the identical shape among four other such stimuli and pointing it out) were not significant. The four tests which yielded significant differences had in common the need for close attention and short-term recall followed by a verbal response. Based on these results, one may hypothesize that (a) malnourished children are deficient compared with well-nourished children in tasks requiring short-term recall, and (b) the

superior performance of the normal children compared with the previously malnourished children is due to motivational and attentional rather than intellectual factors.

The second study was designed to test the two hypotheses as well as to explore a variety of cognitive and behavioral characteristics in malnourished children. The criteria for selection of 11 well-nourished and 17 previously malnourished children were identical to the first study except that the testers in this study did not know which group had been malnourished. In addition to the four tests yielding significant differences in the first study, two additional tests were used to study short-term recall: memory for visual designs and variations of the Knox cube tapping test.

The results of the second study differed from the first. The four tests that originally distinguished the previously malnourished from the control children showed no group differences in the second study. However, the previously malnourished subjects did perform significantly more poorly than the well-nourished children on the two additional short-term memory tests. These results do not support our hypothesis that malnutrition is directly associated with short-term memory capacity, since four of the six measures of short-term memory tests failed to discriminate between the well-nourished and the malnourished children. Another possible interpretation of difference in the results for the two studies is that the malnourished group in the first sample was more severely malnourished than the malnourished group in the second study. Some support for this contention comes from the finding that the malnourished children in the first study had a greater deficit in height for chronological age. A final possibility is that the results of the first study may have been influenced by observer bias, i.e., the examiner's knowledge of which were the well-nourished and the malnourished children of the two groups.

The second hypothesis, which suggests that differences between well-nourished and malnourished children may be due to attention or task concentration rather than cognitive capacity or ability, offers the more reasonable explanation for these findings. The pattern of test performance differences between the two groups in the second study suggests that motivational and attentional, rather than intellectual, factors underlie these group differences. Only when the attentional demands on the children were increased, for instance in the Knox cube test, did the control group out-perform the experimental one. Again, the memory for visual design tests, which require high attention, yielded poor results in the previously malnourished childern, and the failure of these children to improve their performance from trial two to trial three suggests a loss of interest in the task. Furthermore, the matching familiar figures test is considered a sensitive measure of motivation or task involvement and requires the use of systematic visual search strategies, without being inherently interesting. The absence of group differences for the

easy items indicates that both groups were equally capable of searching and finding the correct figures. The poorer performance of the previously malnourished group for the difficult items indicates failure to employ the solution strategies that the easy items demonstrated the children possessed.

Accepting the interpretation that the differences between the well-nourished and the malnourished children are caused by motivational rather than intellectual factors, the problem remains whether these motivational differences are directly related to the health and nutritional history of the child, or whether they result from a sampling bias in which the well-nourished children benefited from advantageous childrearing conditions. Since language development tests are generally considered the most sensitive indices of social class differences and since no statistically significant differences were found between the groups, the sample appears to have been successfully controlled for family differences between the well-nourished and malnourished children.

The evidence suggests that the performance differences may be associated with the poor health and malnutrition suffered by the experimental children. Because of more frequent and prolonged illness and lower energy levels, malnourished children apparently do not develop the normal ability to maintain high attention levels during difficult cognitive tasks. These behavioral patterns appear to persist after nutritional rehabilitation, resulting in the performance diffferences seen in these studies.

Diets of Pregnant Women

Monthly quantitative dietary records were obtained for 58 women in a rural village from the time pregnancy was ascertained until childbirth (15). Marked nutritional deficiencies were noted during the three trimesters for practically all nutrients studied, except iron and thiamine. The deficiencies were more severe during the first trimester, especially for calories, protein, vitamin A, niacin, and riboflavin. Not only was the protein intake low but only 20% of the total dietary protein came from animal sources.

Biochemical Analysis of Placentas

Thirteen placentas gathered in two rural communities over an eight-month period were analyzed biochemically and compared with similarly analyzed placentas of 23 well-nourished women studied in Iowa (16). The Guatemalan placentas contained less total protein, DNA, K, Na, Mg, Fe, and Se than the placentas from the U.S. However, the Guatemalan placentas showed a significantly higher cellular concentration of zinc than the North American placentas. The total number of cells per placenta was calculated on the assumption that DNA concentration per cell is constant (17). The value for the U.S. placentas was 2.370×10^{11} and

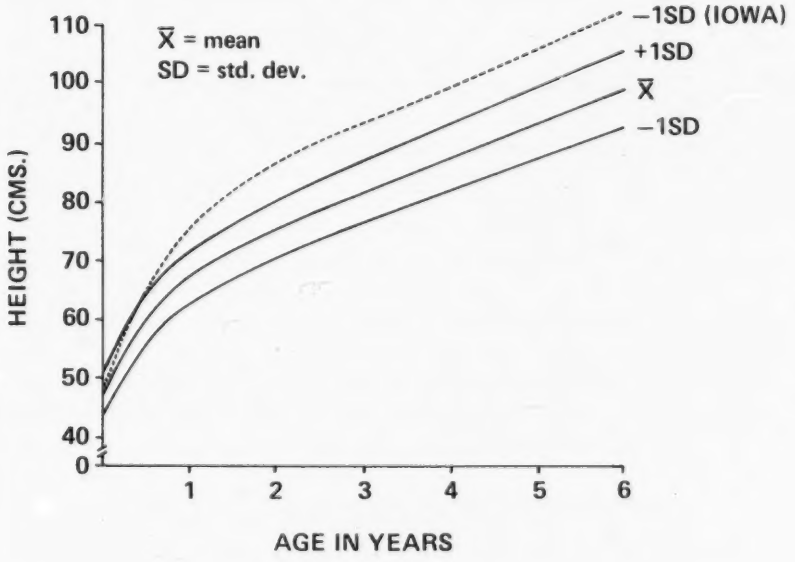
for the Guatemalan placentas 1.663×10^{11}. In view of the severe dietary deficiencies it is reasonable to postulate that the placental differences could be due in part to these nutritional deficiencies. Furthermore, the anatomical and biochemical changes could be responsible for functional alterations, which, in turn, could damage the fetus.

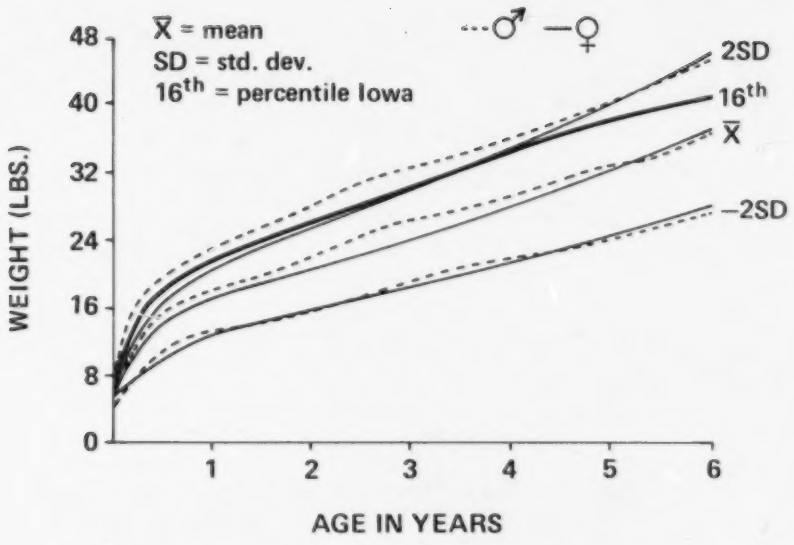
Mortality in Preschool Children

Mortality patterns among children up to seven years old in one village showed that death rates were high during the neonatal period, 64/1,000; highest during the post-neonatal period, 83/1,000; and still high during the second year of life, 52/1,000. Knowledge of specific death rates was necessary to calculate maximal possible attrition over time and thereby be assured of a sufficient number of children in each community at the end of the study.

Diet of Preschool Children

A seven-day quantitative dietary survey of preschool children in one of the villages indicated deficiences in the majority of nutrients investigated. These were most pronounced in the children under two years of age. As was found for the pregnant women, the most severe nutritional deficits were in calories, protein, vitamin A, riboflavin, niacin, and vitamin C. No estimate was made of the amount of breast milk ingested, but breast milk consumption is known to decrease markedly after the first four months of age.





Physical Growth of Preschool Children

Values for height and weight were obtained for 2,800 preschool Guatemalan children representing over 92% of the population studied in eight rural communities; these were compared with the Iowa growth curves (18). Compared with healthy urban Guatemalan infants, rural infants maintained a similar increase in length for the first three months. Beyond this age, the rural children exhibited a relative growth deficit which lasted about 30 months. Comparable growth rate was then achieved, and by 60 months their growth rate was similar to that of healthy urban Guatemalan children. However, the mean height for 6-year-old boys in this sample was two standard deviations below the Iowa standard. The weight of 6-year-old Guatemalan boys and girls was almost one standard deviation below the Iowa standard (Tables 1,2).

Bone development was studied by the Greulich and Pyle method (19) in a sample of 80 Guatemalan preschool children representing almost 100% of their age group in one village. There were marked negative deviations from the standard after 20 months of age, which were accentuated throughout the preschool age period. Also, the second metacarpal cortical thickness of a sample of Guatemalan children was significantly less than the standard of the Fels Research Institute for a North American population (20).

Socioeconomic Factors and Biological Variables

A social class scale was developed which would permit relating

socioeconomic status to biological variables for families with preschool children living in apparently homogeneous villages. Using an arbitrary social class scoring system, three groups of families were compared for adequacy of protein and calorie intake, cortical thickness of bone and the incidence and duration of diarrheal diseases. The differences observed between Group 1, the lowest, and Group 3, the highest were significant at the 0.01 level for these biological variables. Thus, even in small, isolated communities, families can be separated according to socioeconomic status which in turn is related to specific and quantifiable biological variables.

Staff Training and Restandardization

By continuous instruction and standardization of all procedures 70 people were trained during the preliminary study to obtain and interpret data with high reliability. The instruments to assess the independent and dependent variables were validated, and reliability coefficients were obtained by numerous pretesting sessions in villages that were then excluded from the definitive study. Since even under ideal conditions, changes in personnel occur in long-term studies, training of additional staff and restandardization of techniques were established as ongoing procedures.

SELECTION OF COMMUNITIES FOR THE DEFINITIVE STUDY

Criteria for Selection

For methodological and practical reasons a number of criteria were selected for matching villages for the definitive study:

1. Number of inhabitants: 500-1,000.
2. Birth rate: 35-45/1,000 annually.
3. Death rate: 14-18/1,000 annually.
4. Age distribution:

Birth-15 years	35-50%
(Birth-six years)	25-30%
16-45 years	40-45%
55 years and over	5-10%

5. Family composition: Average of five members per nuclear family.
6. Population mobility: 80% or more born in the area 2% annual migration
7. Social isolation: distance to Guatemala City 50-150 km; the nearest community included in the study should be 10 km or more and under the jurisdiction of a different municipality
8. Compact nuclear settlement: 80% of homes within a radius of one km from the research center

9. Housing and community services: 60% similarity among communities
10. Ethnocultural characteristics: 100% Ladino culture, a blend of Indian and Spanish physical characteristics; use of the Spanish language; dress and customs more European than those of Guatemalan Indians
11. Socioeconomic level: average annual income per family, $\$200 \pm \$50$
12. Sociocultural homogeneity: must exist between families and communities
13. Educational level: 80% literacy among population eight years old and over
14. Basic foods: corn and beans
15. Prevalent diseases: Malnutrition, gastrointestinal and respiratory disorders
16. Proneness to immediate change: very limited.

Several other characteristics such as accessibility, predominant economy, land tenancy, and the possibility of change in the area were also considered.

Based on information from the most recent population census (1964) a list of 300 Ladino villages of 300-1,000 inhabitants was compiled. Many of these were eliminated because of their distance from Guatemala City, number of inhabitants, and dissimilarity of ethnocultural characteristics. Lack of roads and dispersed settlement patterns also eliminated substantial numbers of communities. Visits were made to 179 villages, from which 45 were selected for further screening. Only 10 of these 45 villages fulfilled the selection requirements.

Matching the Villages

A family census was conducted in each of the 10 villages to provide information about housing, family size and composition, general sanitary facilities, religion, and means of transportation. In addition to this information, data were gathered on other sociocultural aspects of families with preschool children. A family socioquestionnaire was used to obtain information on morbidity, economic status, household conditions, annual production and consumption of crops, food habits, education, migration patterns, extent of family identification with Ladino culture, social relations with others in the community, intra-family social interactions, type of clothing worn by each member of the family, grooming, and use of free time.

Seven-day dietary surveys were taken by staff assigned to each community to define the food habits and intake among families, especially the preschool children under study.

Prevalence of tuberculosis was recognized as a decisive factor in the final selection of the communities. The presence of this disease could have made the already difficult task of determining the effects of mal-

nutrition on mental development more complicated because of its potentially adverse influence on growth and development. Since the prevalence of tuberculosis among these isolated communities was unknown, a complete photofluoroscopic and skin test survey was carried out. Persons suspected of having tuberculosis were reexamined and a chest X-ray was obtained to make a definitive diagnosis. These studies revealed a relatively low prevalence of tuberculosis, which did not materially affect the matching of the villages.

Anthropometric measurements including height, weight, and left arm circumference and tricipital skinfold thickness were made on all children from five through seven years of age. Psychological tests that focused on incidental learning, intentional learning, memory for digits, picture naming, picture recognition, and memory for sentences were administered to all 5- and 6-year-old children in the four villages.

While the study villages matched well on all of the above characteristics, there were unexplained differences among the total set of villages in both physical and psychological development. Use of the matching criteria, however, permitted the selection of two pairs of villages for the definitive study.

THE DEFINITIVE STUDY

The final design provides for an intensive long-term prospective study of similar groups of children living in two matched pairs of villages in rural Guatemala. All villages receive medical care not previously available to them. All homes are visited regularly by interviewers to obtain epidemiologic, sociologic, and dietary information. Thus, medical treatment and social contacts in both the experimental and the control pairs of villages are designed to be comparable. In one village in each pair a systematic effort is made to provide a nutritional supplement to all pregnant women and to children under seven years of age. A popular low calorie fruit flavored drink is provided in the other (control) village of each pair. The fruit drink was selected as one which the villagers recognized as having no intrinsic food value while at the same time having an intrinsic reward value in the dry climates of the villages.

Approximately 20% of the total population of these villages, which varies from 500 to 850 inhabitants, are children aged six years or younger. The rural economy yields an income of less than the equivalent of $200 a year for each family. The diet is composed largely of beans and tortillas. Projections indicate that about 60 births per year will occur in each village thus providing a new study cohort annually. Mortality in preschool children as well as losses by migration and other causes are expected to reduce each cohort by a maximum of 20 children during the six years of the study. Therefore, the net annual addition will be only about 40 children for each of the two experimental and the two control villages.

The nutritional status of the mothers and children is assessed by a wide variety of direct and indirect measures, including the assessment of bone development, and information concerning frequency and duration of illness. The clinical examinations are based on the Manual for Nutrition Surveys (21), the 1966 INCAP-US Office of International Research Survey methods (22), and World Health Organization reports (23,24); the neurological examinations are based on the methods of Paine (25), Andre-Thomas and colleagues (26), and Gesell and Amatruda (27); and the anthropometric studies are done according to methods described by Falkner (28) and Jackson and Kelly (29). Evidence of morbidity is obtained through house visits every 15 days (30). Seven-day dietary surveys are done in accordance with methods in use at INCAP (15,22). The roentgenograms are scored by the methods of Greulich and Pyle (19) and Tanner, Whitehouse and Healy (31). Cortical thickness (32) and number of ossification centers (33) are also assessed. Hemoglobin, hematocrit, total serum proteins, albumin, globulin, the albumin/globulin ratio, serum vitamin A and carotene, urinary excretion of creatine, urea, and the urea/creatinine ratio are determined (34-39).

It is too early to draw any firm conclusions from the longitudinal study, particularly in the neurological and behavioral areas. It is of interest, however, that data have been obtained relating maternal nutritional status during pregnancy and birth weight (40,41). In the months preceding initiation of the longitudinal study it was found that the average infant birth weight for 51 infants was 2.99±0.48 kg (Ave.±s.e.). By controlling for parity of the mother, maternal height (as an index of long-term undernutrition), and sex of the infant, a difference of 305 gm was found between birth weights of infants born to mothers who consumed less than 1,800 calories vs. more than 2,200 calories daily ($P<0.05$). One hundred and thirteen pregnant women have also been followed to term in the four study villages. Eighty-five percent of the mothers who consumed supplement on more than 60 days during pregnancy had babies with birth weights equal or greater than 3.0 kg; in comparison, only 50% of the mothers who came to the center less frequently had babies with comparable birth weights. Put in other terms, those mothers who consumed more than 30 liters of supplement during pregnancy gave birth to infants with weights similar to the standards for industralized countries; almost none of those in the control villages did. These observations suggest that the nutritional supplement is having an effect such that differences in behavioral development due to malnutrition may be detected, if such differences exist.

CONCLUSION

Evidence from studies with experimental animals suggests that both moderate and severe protein-calorie malnutrition, at critical periods, can produce adverse changes in physical growth and mental development. Evidence from human studies also suggests that severe, long lasting protein-calorie malnutrition in young children may be fol-

lowed by modifications in behavior and mental performance. However, the exact mechanism by which the effects of protein-calorie malnutrition are mediated remains to be determined. The present intervention study, under more carefully controlled conditions than have heretofore been possible, should provide a great deal of information on the interaction between malnutrition, behavioral development, and the social factors in an underdeveloped community.

NOTE: Dr. Canosa and Dr. Salomon were with the Growth and Development Unit, Institute of Nutrition of Central America and Panama, Guatemala at the time of the Conference. Dr. Canosa is currently with the Instituto Nacional de Prevision, Clinica Infantil, Valencia, Spain. Dr. Salomon is now with the Universidad de Brasilia, Brasilia, D.F., Brazil. Dr. Klein is with the Division of Human Development at the Institute of Nutrition of Central America and Panama. This study was supported by the Pan American Health Organization, World Health Organization (PAHO-WHO), under Contract PH43-65-640, National Institute of Child Health and Human Development, National Institutes of Health (NICHD-NIH), to the Institute of Nutrition of Central America and Panama (INCAP).

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V

Cultural Stability and Social Change in North American Indians

Social Structure and Child Rearing Practices of North American Indians

Murray L. Wax

The Future of Native Americans

Marjorie M. Silverberg

200/201

SOCIAL STRUCTURE AND CHILD REARING PRACTICES OF NORTH AMERICAN INDIANS

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The majority of those people who are defined as Indians are also defined as poor. It is the visibility of Indians as poor that generates conferences and books such as the present one. We would not be interested with the same intensity and the same orientation if Indians were not poor.

When I say that Indians are defined as poor, I mean to direct attention to the fact that poverty is more than a condition of an isolated individual or isolated group. Many peoples throughout the world and throughout history have existed in conditions of great hardship and misery: the Eskimo of the recent past; the contemporary Bushmen of the Kalahari Desert. Poverty is more than hardship; it is a relationship among groups within a society. As that pioneer sociologist, Georg Simmel pointed out (1), poverty is a relationship characterized by receiving charity. While the transfer of gifts among peoples is a symmetric relation (2), charity is asymmetric: one group gives; the other receives.

Simmel may seem out of date. We don't talk so much of "charity" nowadays, but yet the same configuration endures. The poor are no longer targets of charity; they are the targets of programs. Welfare workers, missionaries, public health workers, social reformers of all types and interests descend on Indian groups and aim programs at the heads of the Indian people. In one reservation I know, consisting of

about ten thousand Indians, there are well over a a hundred such programs. (At that point I lost count.)

Being poor and being the targets of programs makes the Indians look homogeneous. Many writers, e.g., S.M. Miller (3), have pointed out that such labels as "poor" and "lower class" lump together into a common category persons who are quite heterogeneous in their backgrounds, their problems, and their abilities to cope with their lives. Charles Valentine (4) argues that the whole notion of "a culture of poverty" or of cultural deprivation derives from the perspective of those who administer programs, since the poor appear only as statistics in these programs and not as the diverse groups they really are (5-7). Those who have lived among the poor, who have conducted ethnographies of the lower classes (8-12), emerge with accounts of radically different modes of life. Turning to Indians, the same is true, since those peoples classified as Indians by the invading Europeans were of vastly disparate social structures and vastly different adaptations to their environment. Moreover, as has been pointed out by Spicer (13), the multitude of programs directed at Indians by the multitude of invaders--programs designed by missionaries of different creeds, by the military of different nations, by traders, government administrators, educators, and the like--have served to inaugurate differences among Indian populations that once were homogeneous.

Typically, in a reservation area, the observer can find Indians of several degrees of wealth, of several degrees of education, of a diversity of religions, and of a diversity of orientations toward the impingements of the exterior society. I cannot hope to sum this up in a short paper, and anyway, the research simply has not been done. I am going to focus on poor Indians, and I am going to focus on those persons who participate in the kind of community life I can perceive as Indian.

These Indian communities are characterized by a social structure that is egalitarian and that is tightly integrated, yet informal. It is a social structure that is hard for administrators to perceive and almost impossible for them to deal with. It is a social structure that even skilled ethnographers find difficult to perceive and to describe. Most ethnographers I know want a system with clearly demarcated institutions and clearly systematized offices and responsibilities--the ethnographers are like the administrators. Instead, they encounter a system that seems so fluid that it is exasperating; the observer sees the plans carefully laid by reformers and administrators, plans seemingly with much potential, go so madly awry the effect is comic (or tragic). I have been in situations--thank God, as a detached observer!--where plans have gotten so fouled up that the situation becomes as maniacally funny as a Buster Keaton comedy. And yet, while these great plans with great potentials are in this state, and the Indian community is seemingly in total disorganization, a ceremonial may be held with style and elegance, and everyone takes it for granted, while no one seems to be personally responsible.

The word "Indian" and the word "community" can be a great source of trouble both for administrators and ethnographic observers. Administrators are trained to proceed by general rules and to apply them to the largest social configurations possible. Administrators look at a reservation of ten thousand people and they want to see it as "a community" with a social unity and an ability to cooperate together for the joint accomplishment of projects and programs. But functioning Indian communities tend to be considerably smaller. This characteristic may be a question of a lack of resources; it may also be a question of poverty and powerlessness, so that the possibilities of overarching integration have been preempted by exterior agencies. Be that as it may, I urge that the focus be on small local units, and attention be directed first and primarily at the patterns of sharing and the patterns of giving gifts. I think it will be found that there are extended families which maintain a common daily economy and share work and food on that basis. Further I think that there are clusters of these extended families--clusters which are a function of transportation and of the ability of the members to come together regularly for ceremonial activities--which exchange gifts and share provisions with each other on a weekly or monthly basis. These are real communities, and they do get things done. Mainly, they stay alive, they preserve the integrity of the group, they function as a faction vis-a-vis exterior and parallel groups (14).

The kinds of children I know and have worked among are brought up within these Indian communities. Now, if one is the kind of social observer who sees these Indian communities as disorganized, and if one is the kind of observer who uses a neo-Freudian social psychology, then he will assert, as many have, that Indian child rearing is "permissive." This, to me, is a gross error, and I am amazed that it can be maintained; the reservation children I have seen are incredibly well behaved. White people often say Indian children are "shy," and they do deport themselves in a fashion that fits this white term, but the application of the term indicates that these children are extremely careful about how they conduct themselves. If these children were the undisciplined products of permissive child-rearing, the observer surely would not be labelling them as "shy"!

Another thing whites, especially school teachers, say of Indian children is that they are not competitive. Again, this is a partial truth, but it fits the experience of the school teacher, for she observes that if she calls on one child and he does not know the answer, no one else will admit knowing the answer. No child will publicly show himself the superior of another child in his classroom. In most of the schools I have seen, the children will compete indirectly by responding to written quizzes, wherein some do better and some worse. But in the Kwakiutl school that Wolcott attempted to run for a year (15), even this would not work, for the children would help each other with their seat work, and this was so much the case that he never did discover just how much or

how little many of his pupils actually knew. Yet the characterization of Indian children as "non-competitive" is palpably a gross error. All one has to do is watch the basketball team of an Indian high school deal with the team of another high school. Even within a single class, all one has to do is pit the boys against the girls in a spelling bee or an arithmetic contest, and there will occur all the competition one could wish.

Rather than continue this game of setting up stereotypes to mock, I will assert the matter positively. Perhaps the best terminology comes from Herbert Gans' studies of the lower class Italians in Boston (10). Gans says that they are "person oriented," and he contrasts this with "object oriented" individuals of the middle class. It seems to me this is the key to understanding Indian child rearing. It is person oriented. The nature of this upbringing is such as to place great value on relationships with other people in the local community and to place negligible value on objects. The child learns to define himself in a relationship with other people, and not in relationship to such abstractions as "career," or "occupation," or money. White reformers stress objects. Indians stress personal relationships.

What kind of child rearing produces children who are person-oriented and who display these traits that whites label as "shyness" and "non-competitiveness"? I want to focus on the juvenile stage and early adolescence and to direct attention to the peer society. Relatively early in life, Indian children begin to spend most of their time with other children from the same local area. They spend little time interacting with their parents, except for occasional appeals for food and comfort. Indian parents encourage this autonomy. Many white reformers have been displeased; they accuse Indian parents of being permissive or indifferent. They think Indian parents are not doing their job. This is because white reformers are oriented about a child-centered home in which parents continually intervene in the activities of their children. Indian adults live in an adult-centered kin group where children are welcome, but are not the focus of attention and activity.

Thus, from the juvenile stage onward, the conduct of Indian children is shaped by their peers. It is the peer society that instructs its members in the conduct whites label "non-competitive," since this means that a boy should not show up his buddies in front of outsiders. Today many whites tend to derogate the socializing role of the peer society, yet the great Swiss psychologist, Jean Piaget, demonstrated that it is that society which instructs its members in such fundamental virtues as justice and fair play (16). Until recently most Americans--and this includes some great national leaders--were raised more by their peers than by exterior agencies.

The researches I have performed in conjunction with my associates, especially Robert V. Dumont, Jr., of Fort Peck, Montana, have shown that the peer society has a major effect on how Indian children relate to teachers and schools (17). In the intermediate grades--fourth, fifth, and

sixth--the children engaged in a process of teasing which serves to disrupt the communication between the teacher and any individual pupil, and to reduce the effective content of the teacher-pupil interaction. In the subsequent levels, junior high school and beyond, the teasing diminishes if the group is stable, since the peer society has established its dominance. I want to emphasize this operation of the peer society since some social scientists persist in regarding Indian-ness as an individual trait, like blood quantum. Then these social scientists think somehow that an Indian is an Indian in splendid, individual isolation.

What I have tried to argue in this paper is that to be an Indian is to be a participant in a small local band of fellow Indians (18). This is true whether we are focusing on adults or children. If we want to understand the experiences of Indian children, we have to look at the totality of their experience, and this means that we have to see how that child fits into his local community.

In regard to matters of nutrition: at Pine Ridge the Indian people would tell me that the children lost weight during the summer and gained weight during the school year. I don't know whether that is still true, but if it is, it suggests that the food the children get in the schools is a significant part of their diet. Occasionally adolescents told me that they had perfect attendance at school and explained: "I never missed a day, because it was the only good meal I got." My wife visted in many homes and found that in those of the poorer people, the parents simply did not have the food to feed their children. As one mother remarked: "We sent our boys to the boarding school so that they would not be hungry." These statements do not reflect parental carelessness or unconcern.

And, while we are busy congratulating ourselves on how Indian children are being nourished in schools, we might reflect on the social consequences for familial and communal integration. During the past decades, researchers have become aware of how the social role of the male in lower class families has been eroded because he could no longer be the primary provider of wages for his family (7). We are now witnessing a parallel erosion of the role of the female in lower class families as exterior institutions (including boarding schools and Head Start programs) provide food and nurturance as well as instruction that undercuts the norms of the parental household (19).

Returning to purely nutritional matters, I would like to note that the trading posts on the Pine Ridge Reservation carried a surprising amount of what we would call luxury foods. I have noticed that some Sioux children, on being given money by their parents, would head eagerly for these displays of oranges, bananas, and peaches rather than for the candy counter.

I would like to make one final point. In some of the public schools I have observed, there is a free lunch program sponsored by Federal monies for Indian children. The administrators of these schools have told

me: "We don't believe the children should get something for nothing." What this means is that the children are sent to work in the dining room of the cafeteria for that free lunch. That is the American tradition. You work for everything you get, even if what you are getting is in the fulfillment of treaty obligations or of compensatory legislation. Well and good, but should a child work for over an hour in order to receive a 25-cent "free lunch"?

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THE FUTURE OF NATIVE AMERICANS

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The future of both reservation and urban Indians deserves immediate concern and action. Close to 827,000 Native Americans (1) live on approximately 300 widely scattered reservations or Federal land, but large numbers of individuals have migrated to cities. Figures for the number of urban Indians are unavailable since the Federal government often loses contact after they leave the reservation; some claim that a majority of Indians now live off reservations. In the city, the traditional services of the Bureau of Indian Affairs (BIA) and of the Indian Health Service (IHS) are not available to those who left either by choice or as part of a government relocation program; some of the specialized programs of the Office of Economic Opportunity (OEO) fall in the same category. Other Federal or local agencies, under the misconception that Indians are already receiving these funds, may deny the help the urban Indians need and to which they are legally entitled. Not infrequently Indians return to the reservation because of their need for these services.

President Nixon has estimated that about three-quarters of urban Indians are poor (2). He described all Native Americans as the most isolated and deprived minority in the U.S. based on any measure of income, health, education, and employment. Recently, however, new policies and legislation have been introduced in Congress which provide potential opportunities for Indians and Alaska Natives to run their own institutions and programs and to determine their own destiny.

THE RELATIONSHIP BETWEEN THE FEDERAL GOVERNMENT AND NATIVE AMERICANS

In the past, termination (assimilation) was advocated as Federal policy under a congressional resolution passed in 1953. This resolution declared that Indian Tribes would eventually lose any special standing under Federal law, the tax exempt status of their lands would be discontinued, Federal responsibility for their economic and social status would be repudiated, and the Tribes dismantled. Tribal property was to be divided among individual members, who would then be assimilated into the larger society.

In July 1970, the Administration stated its support of a new policy of self-determination, guaranteeing the historic relation between the Federal government and the Indian communities unless the Indians themselves wished to terminate it. At the time of the policy announcement, only 1.5% of the BIA's programs directly serving Indians were run by Indians and only 2.4% of IHS programs were run by their recipients (2).

Since then, legislation has been introduced to provide for assumption of control and operation by Indian Tribes and communities of various programs and services now provided by the Federal government. Other proposed legislation would make loans available for financing the economic development of individual Indians and Indian organizations, including loans for education, and would create an Indian Trust Counsel Authority within the Executive Office of the President to assure independent legal representation in conflicts concerning land and water rights. The Departments of Justice and Interior now provide counsel both for Indians and for those negotiating with them, an acknowledged conflict of interest. Other bills would allow Tribes to regulate trade and grazing rights on their land, and would provide civil service benefits to employees of the Federal government who choose to work directly with Tribal organizations. This latter innovation would encourage experienced personnel now working for the government to work directly for Tribal organizations without sacrificing their Federal employee benefits. Still another bill would direct funds for education to the Indians themselves rather than to school districts as is presently done.

It has also been proposed that the BIA be upgraded within the Federal government. Recent internal reorganization of the BIA has redrawn lines of authority to bring decision-making powers closer to the Tribes and personnel dealing with them.

SELF-DETERMINATION IN EDUCATION

If education is the key to higher living standards and pride in one's heritage, community control of schools is one of the means of obtaining the key. Dropout rates throughout Native American cultures have been 50% higher than those of the rest of the population; few have continued on to college; and the average schooling of the Navajos over 25 years old

has been less than five years. This has been caused partly by the use of English as the primary language in the school, even though native language has been spoken at home. The predominance of so-called Anglo teachers, who knew little of the cultures or languages of the children they taught, has also had an adverse effect (3).

An experiment begun in 1967 in Rough Rock, Arizona and another at the Navajo Community College the following year have proved successful prototypes for community control. Rough Rock, serving youngsters 6 to 16 years, was taken over by a five-member school board chosen from the Navajo community and was given complete authority. While Navajo is the primary language now, English is also taught and replaces Navajo as the first language when the students become proficient. Courses in Navajo culture and crafts are offered to all age groups, with adults participating in teaching as well as taking courses. Initially the faculty was 10% Navajo; four years later the number had risen to 69%. As in most reservation schools, two-thirds of the students live in dormitories because of poor roads and the great distances from home. However, parents who were recruited to act as housemothers on a rotating 12-week basis have proven highly successful in their jobs.

The Navajo Community College was the first college ever established on an Indian reservation. It has an open admissions policy and offers programs geared mainly to fit the needs of the Navajo students. The curriculum consists of Navajo language, history, culture and crafts, but also includes numerous vocational subjects. Conventional classes in science and the humanities are offered.

These two experiments were pioneered by Robert A. Roessel, past Director of the Arizona State University's Indian Community Action Center. Their apparent success has already encouraged Tribes in eight states to attempt to establish, or assume control of, their own educational institutions. Replying to criticism that both schools were on a "culture kick," and might be turning out merely "well-adjusted illiterates," Roessel claimed the over-emphasis that may have occurred was inevitable to counteract the de-emphasis in schools on Indian culture in the last 100 years. He claims that Indians have at last won the right to be wrong, a freedom other Americans have long enjoyed (3).

THE FEDERAL AMERICAN NATIVE

Virtually all of the proposed legislation deals with Federal Natives, those living on reservations or in designated communities. While self-determination is a necessary prerequisite for progress or betterment of present conditions, the endless years of dependency make the transition painful and difficult. The concept of self-determination is complex, for to some it may mean the strengthening or rebirth of original cultures and for others, Westernization, or a combination of the two. However, the present conditions of reservation Indians are generally so desperate

that this issue is almost secondary to immediate aid in health and education as well as employment.

Federal planners must recognize the need to make aid usable. One approach is that of training professionals and others dealing with Native Americans much as the Peace Corps trains its volunteers. If understanding is a prerequisite for problem solving, so the helping agencies need to understand the people and their customs as well as the feasibility of the type of aid offered. Earlier in this book Cravioto and Canosa and his group have documented the significance of thorough knowledge by the research team of the customs and life styles of the population as well as the importance of careful education of the people concerning the project to be done and the values for them from participation. Owen and his group and Reisinger, Rogers, and Johnson also enlisted the cooperation of the Apache and Navajo tribes through careful preparation for the surveys they carried out. Involvement of the people to be served is the first step in providing aid. However, imposition of Western concepts and techniques on a group without proper explanation of the goals and immediate and long-term benefits in their terms has little lasting value. An analogy might be treatment of a serious, infected wound by a physician through the use of antibiotics and dressings. The patient may change the bandage, but reject the medication through his faith in traditional remedies, or lack of understanding of its importance, or even hostility towards the white man and his medicine.

Both Federal and tribal representatives need to recognize their own responsibilities to devise programs in which the aid is appropriate, acceptable, and usable, both culturally and logistically. The goals and methods of the programs must be understood by those using them. Above all, such programs need to be directed to the actual needs of the people rather than designed as a means of serving other purposes, such as the surplus commodity program administered by the Department of Agriculture. This program was originally intended to maintain prices to farmers through purchase of specific (surplus) products. The program is now used to feed the poor with the food distribution depending on the supply or oversupply of a given crop at a given time. Something is not always better than nothing and programs like this may damage or even destroy rapport between government and the people it is charged to serve.

If the dominant culture does not understand the Native one, so the reverse is also true. Native groups frequently are unaware of the social and economic costs of the attractive products available to them. Lantis illustrated this in her description of the introduction of snowmobiles, the usage of which she considers probably the most revolutionary change occurring throughout the Arctic region. The cost of the snowmobile may be as high as $1,000, and its use changes the type of economy required to maintain it. The ease, speed, and comfort of snowmobiles, its useful-

ness for avoiding long periods away from home, and its prestige value make it attractive to own. However, customs formerly necessary for survival have become obsolete, and methods of coping with new ways of life have not been firmly established. Dependency on a salary and the availability of a job are two important factors that need to be considered if one buys a snowmobile.

It would be naive to assume that the Federal government and the Native American people will unite spontaneously to solve these problems without a great deal of pressure and problems. The need for immediate, probably massive, aid seems essential, but without careful, thoughtful planning on both sides and evaluation of the effects, such help may still prove ineffective. The participation of Native Americans as health aids and other types of professionals and subprofessionals is a beginning.

THE URBAN NATIVE AMERICAN

If the problems of the Federal Native American are formidable, those surrounding urban Indians are no less so. Indians are leaving their lands in large numbers because of rapid population increase--2.2 times that of all U.S. races (38.5/1,000 in 1968) (4)--and the desire for jobs and a better life. This trend will probably continue because of the youth of the population: the median age of reservation Indians is 17 years compared with 28 years for the general population (5). Vine Deloria, Jr., a Standing Rock Sioux Indian who is past Executive Director of the National Congress of American Indians, believes the future of Indian affairs lies with urban Indians because of their large numbers and the availability of jobs in cities as compared with reservations (6). Deloria recommends Federal funding of comprehensive national programs for training and employment placement; ideally these should include close coordination of individual Tribes with Indian Urban Centers. The Urban Centers would consist of enclaves built near towns and smaller cities, an example being the Sioux City Indian Center established in 1969 as a focal point for coordination of employment, housing, education and related activities for Indians in four states. The Administration has already authorized the establishment of seven Urban Indian Centers by OEO and the Department of Health, Education and Welfare to coordinate services between Federal, state and local governments for the benefit of urban Indians

Deloria believes such a program can be accomplished without additional funds by redistributing money now appropriated to support programs for so-called Federal Indians--those living on reservations and in other specified areas. He suggests the transfer of the BIA to the Department of Commerce and ultimately a merger with the Economic Development Administration as a special Indian section. This would allow the matching of development projects with available programs in other government agencies while at the the same time promoting and

facilitating opportunities for Indians in the private business sector. Finally, he proposes that Congress recognize the basic right of Tribal sovereignty and the establishment of eligibility of Tribal governments for all Federal programs available to counties and cities.

The problems of helping urban Indians are massive and will require a variety of new approaches and innovative techniques. Anthropologist Margaret Lantis has suggested that, ironically, ending a traditional practice is often easier than learning a completely new pattern, or a so-called modern technique. Concern about people's resistance to change might be better spent on projecting the consequences of premature acceptance of change. An inadequate replacement for a traditional practice may produce situations worse than the original ones. An example is the substitution of bottle for breast feeding where preparation of formulas, sterilization of bottles, and establishment of feeding schedules create totally new life patterns essential to the success of artificial feeding.

Understanding of a problem is a prerequisite for the motivation to solve it. Consequently, education to harmonize the Indian and non-Indian value systems, i.e. understanding, must be offered prior to technical, vocational and liberal education (7). If this does not occur, most programs will be largely thwarted because of the conflict of values. Private efforts by Indians and non-Indians in organizations like Americans for Indian Opportunity are attempting to accomplish this in both urban and reservation areas with individuals of all ages.

COMMENT

American Indians and Alaska Natives are under direct or indirect pressure to part with their land--in Alaska, with its enormous oil reserves, in the Southwest, with its coal now being strip-mined and processed for electricity for five western states, and in other areas. What appears as feast--jobs and money--to some, appears as famine--loss of land, which is considered sacred--to others. The fear of those opposed to leasing their property to outsiders is that land has not only religious meaning but realistically serves as insurance against dependency on the white, urban economy when the land is productive. Without possession, Native Americans fear they will end up as strangers on their own land; until the present time this largely has been the history of the Indian. Many feel that assimilation would be a disaster for Native Americans and for the country. At the same time, the conditions under which most Indians currently live are equally disastrous. The problems have been officially recognized; the first step has been taken; the real work is yet to come.

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VI

Nutrition Research and Community Service Among Native American Populations

Summary and Recommendations

Marjorie M. Silverberg, Merrill S. Read, and Willliam M. Moore

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SUMMARY AND RECOMMENDATIONS

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Research to meet human needs, whether it attempts to determine the causes of cancer or the effects of undernutrition, cannot ignore the complexity of the individual nor the environment in which he lives. The majority of malnourished children are found among the poor who simultaneously are exposed to excessive pre- and peri-natal risks, to frequent childhood diseases, and to other environmental, social, economic, and cultural adversities which in turn may interfere with normal maturation. This combination of deprivations converges on the malnourished child resulting in lowered resistance to infections, retarded growth, and, possibly, intellectual and behavioral changes. The urgency of understanding the complexities of malnutrition has prompted the preparation of the papers in this book and the recommendations which follow. It is hoped that this summary will help in the design of improved service for the present generation of Native Americans and in sparing future generations from the conditions which have been documented here.

THE NUTRITIONAL STATUS OF AMERICAN INDIANS, ESKIMOS AND ALEUTS

Nutritional Surveys

The surveys conducted on Navajos in Lower Greasewood, Arizona, by Reisinger, Rogers, and Johnson; on White Mt. Apache preschool children in Arizona by Owen, Nelsen, Kram and Garry; and on the popula-

tions served by the Indian Health Service (IHS) as summarized by Carlile, Olson, Gorman, McCracken, VanderWagen and Connor, showed that most Indians and Alaska Natives demonstrate mild to marked deficiencies in a number of specific nutrients. In the 200 Apache children studied by Owen's group, the mean intake of calories, calcium, riboflavin and vitamins A and C were substantially below those considered sufficient to meet normal needs. Reisinger and his group found marginal iron deficiencies in a large percentage of the older Navajo population, although the diet evaluations suggested inadequate food intakes in the entire sample. The four studies summarized by Carlile and his colleagues also showed deficiencies in vitamins A and C and in calcium, and borderline protein intakes, except for Eskimos, for whom protein comprises one-third of the caloric intake.

Carlile and his group reported the clinical diagnosis of malnutrition in only two or three pediatric patients per 1,000 treated and discharged from IHS hospitals, except in the Navajo area. In the Navajo area in 1968, 217 hospital discharges were diagnosed as having malnutrition, totaling 5.6% of the total discharges for the group from birth to four years of age; one of these children demonstrated kwashiorkor. In addition, 119 or 3.1% of the total discharges in that age group were treated for anemia. Van Duzen (1) in a five-year study from 1963-1967 of 4,355 admissions to the IHS hospital in Tuba City, Arizona, reported 616 diagnoses of childhood malnutrition based on the criterion of weights below the expected norms for chronological age; 15 of these demonstrated kwashiorkor and 29 had marasmus. During this period nearly 15% of all the 1,455 admissions under five years old had some form of associated malnutrition. French (2) also found a deficiency in vitamins A and C and possibly other nutrients in her study of 139 Navajo infants from 0-24 months of age. Twelve infants from this population had been hospitalized for malnutrition and 10 for anemia.

In all the surveys growth rates were reported to be well below the norms based on the Iowa and Boston standards. In the survey of 167 Navajo preschoolers cited by Carlile and co-workers, nearly one-third of the children were below the third percentile in weight. Among the Navajos in Lower Greasewood studied by Reisinger's group, 73-83% of children of both sexes fell below the 50th percentile in weight and height. Of the Apache children studied by Owen and colleagues, about 38% of the children were below the 10th percentile in height and 18% below the 10th percentile in weight. They found the pattern of growth underachievement, dietary intakes, and biochemical evidence of undernutrition of the Apache children to be similar to findings among the impoverished children in rural Mississippi (3). Among Alaska Natives, persistently slower postnatal weight gain has been shown; the average height of Eskimo infants six months of age was close to the fifth percentile for white children, while the ratio of weight to height was consistently higher in these children. The findings by Moore of little or no

secular increase in height and the possibility of a relatively small secular increase in weight in selected groups of North American Indians differ from those in other populations in the U.S. Possibly full genetic height potential has not been achieved, and changes in dietary patterns may have predisposed to increasing weight for age without correspondingly large increases in height. Based on limited evidence, the Native Americans probably have not shared equally in the generally prevalent secular trend in physical growth. However, additional documentation is required as is more extensive inquiry into the responsible factors through the monitoring of new service programs or the implementation of controlled prospective studies.

Specific Factors Influencing Decreased Growth

Malnutrition during infancy and childhood reduces body size prior to adolescence due to multiple effects on developmental processes. In an earlier article in this volume, Garn observed that malnutrition delays sexual maturation significantly in conjunction with ultimate reduction in total body size. The resultant individual is sexually mature at a much smaller size than is normal in well-nourished populations. Epidemiologic data suggest that such a person is less capable of supporting a pregnancy to full term and frequently produces a smaller infant (4). Dayton, Filer, and Canosa have reported fewer cells in the placentas of malnourished Guatemalan women compared with placentas from well-nourished women in Iowa (5), suggesting a mechanism whereby fetal growth may be affected under conditions of maternal malnutrition. Animal studies suggest that the effects of maternal malnutrition may be carried over to successive generations of offspring in spite of an adequate diet for the offspring (6,7). This raises the possibility that malnutrition in one generation not only may predispose the next generation to risk but also may adversely affect future generations.

The synergism between nutrition and infection is well documented (8). Although intestinal parasites may be endemic in many populations, more deleterious consequences result from the frequent bouts of diarrhea and of severe upper respiratory infections and their complications, as well as of other childhood diseases (9). Infections worsen nutritional status in several ways. Appetite is reduced and solid food may be withdrawn, to be replaced by less nutritional gruels. Infections may require the diversion of energy resources from growth processes to defense mechanisms. Even infections as mild as immunization with a live virus can cause a stress reaction resulting in increased nitrogen and vitamin loss in the urine.

In all of the surveys of Native American populations, a significant incidence of diarrhea and hospitalizations, or both, was reported. Overall, the average death rate for gastroenteritis for infants under one year of age during 1965-67 was 8.4 times as high as for all races in the U.S., and was 7.7 times as high for children one to four years old (10).

Undoubtedly, the increased body size and the earlier sexual maturation of people in developed countries reflects reduced numbers of infections as well as improvement in nutritional intake from infancy through adolescence. Programs to help Native Americans must take both facets of the problem into account if they are to be successful.

DEVELOPMENTAL CONSEQUENCES OF MALNUTRITION

Neurological Effects of Severe Malnutrition in Animals and Humans

Severe protein or calorie malnutrition has been shown to permanently retard cell division in rat brain and consequently to reduce the number of brain cells ultimately produced. Winick reports that malnutrition during the postnatal period prior to weaning has about the same effect on brain cell number as does maternal dietary restriction during pregnancy. Furthermore, the animal exposed to both pre- and post-natal malnutrition exhibits a much greater deficit in total brain cell number by the time of weaning than would be expected by adding the effects of each alone. Winick also found that other changes occurred in rat brain as a result of severe malnutrition: a delay in the migration of cells within the brain and the retardation of myelin synthesi[illegible]rmanent effects on cell number are obtained only when the malnuti[illegible] is imposed during the two critical periods of rapid brain growth, namely prenatally and early postnatally; later malnutrition reduces the size of the brain cell but this effect appears to be reversible by nutritional rehabilitation.

Winick has found that the number of cells in human brain also is permanently diminished by severe protein-calorie malnutrition during the period of most active cell division--during gestation and the first six months of postnatal life. Three of nine infants who died of severe malnutrition showed effects similar to the "doubly deprived" rats (11), with only 40% of the expected cell number present, suggesting that they had been born to mothers who themselves had been nutritionally severely restricted during pregnancy.

These findings clearly suggest that not only the timing but also the duration of malnutrition is critical, since both appear to influence the ultimate number of brain cells. Therefore, within certain limits, the number of cells ultimately formed in the adult brain may be programmed during pre- and post-natal life, with malnutrition appearing to play an important role. Reversal of the malnutrition-induced retardation in brain cell number will occur only if rehabilitation begins early enough in the phase of cellular proliferation. In practical terms, it is most desirable that preventive programs be directed at both the pregnant woman and the young infant.

Behavioral and Physiological Effects of Severe Malnutrition in Animals

Recognizing that malnutrition not only influences body size but also

may alter the cellularity and composition of the central nervous system, it becomes doubly important to determine whether these changes are accompanied by changes in behavior or mental development. Much work has been done on this question (12). Not all of the answers are yet at hand although the results are beginning to form a logical pattern. More work, however, is sorely needed with man's closest phylogenetic relative, subhuman primates.

Barnes is among the investigators who have most consistently pursued answers, using rats and pigs as experimental models. The results of his work, and that of others, particularly the group in Czechoslovakia, have been summarized in his chapter earlier in this book. His data illustrate that postnatal protein deprivation at a level equal to half that necessary for normal growth will markedly decrease growth and also alter behavior. He has shown that after rehabilitation the deprived rats ate 15% more than their non-deprived littermates; they also drank 40% more water per unit of body surface, but body composition decreased rather than increased in fat content. Upon sacrifice the deprived animals had enlarged adrenal glands. Apparently the observed abnormal eating behavior was a reflection of a fundamental alteration in body metabolism. In learning situations, the deprived animals performed significantly less well while also demonstrating elevated levels of excitement or overreaction to painful stimuli on avoidance tests. They were less responsive on extinction tests when pleasurable rewards were changed to unpleasant ones. Maternal malnutrition similarly yields offspring that perform less well on a variety of behavioral tests. Identical results also have been obtained with pigs: animals severely deprived of protein postnatally and then rehabilitated were unable to extinguish a well established conditioned response and also exhibited elevated levels of excitement or overreaction to unpleasant stimuli. When not subjected to test situations or otherwise stimulated, both species of undernourished animals tended to be apathetic and inactive.

Interpretation of the results of these and similar animal studies is difficult. Food rewards are often used in experiments with rats, which may strengthen or change the motivational drive due to hunger responses. Often postnatal, pre-weaning nutritional intake in rats is achieved by increasing or decreasing the number of young suckling on the female; behavioral scientists caution that this variation in environmental stimuli could influence test results. In the pig studies, the elevated levels of excitement and the overreaction to stimuli may confuse the interpretation of other forms of learning tests utilizing adversive stimuli for reinforcement.

Cowley and Griesel have reported interesting findings in their studies with offspring of severely malnourished rats (6). There was a significant delay in the timing of developmental landmarks such as rolling over, opening of the eyes, and learning to walk in those animals that were deprived; further delay occurred with each generation that was

raised on the deficient diet. More than one generation of rehabilitation was necessary to overcome these changes, thereby mimicking a genetic effect. The delay in developmental landmarks parallels remarkably the recent report of significant changes in the structure and composition of brains of rats born to malnourished mothers and to their offspring as well, in spite of an adequate diet (7).

Behavioral Studies in Humans

Animal studies, no matter how carefully designed, cannot provide a definitive answer to the question of the association between nutrition and mental development in man. First of all, each species has its own pattern of development of the central nervous system and other organs so that the impact of malnutrition at a given age has been shown to vary from species to species. In the case of mental development, it can be markedly influenced by the nature of the surrounding environment. None of the lower animal species has the same set of complex environmental stimuli as man; this is particularly true in the case of naturally occurring malnutrition which is accompanied by poverty and a host of other potentially depriving circumstances for human development. Multidisciplinary longitudinal studies of the multiplicity of factors affecting human development are needed. Two of these are described earlier in this volume; only preliminary results from one of them are currently available.

In the Guatemalan field study, two preliminary investigations were done on 5- and 6-year-old children recruited from a nutritional rehabilitation day care center. In the first study 20 children who had recovered from second or third degree malnutrition were matched with 10 well-nourished children from the same family pool. The control group performed significantly better than the previously malnourished group in four of six mental performance tests: memory for sentences; memory for digits; memory for incidental learning; and memory for intentional learning, all of which require close attention and short-term recall followed by a verbal response.

The second study was designed to determine whether previously malnourished children were less competent in tasks requiring short-term recall or whether poor performance was caused by motivational and attentional, rather than intellectual, factors. The results of the second study on two other similar groups of children showed that previously malnourished children did not differ significantly on tests of short-term memory. The pattern of test performance differences in both studies suggested that motivation and attentional factors underlay the group differences. Because the children were well-matched in all other factors except their nutritional state, the investigators believe that performance differences may be directly associated with the poor health and malnutrition suffered by the previously malnourished children. Because of more frequent and prolonged illness and lower energy levels,

malnourished children may have a different experiential foundation and may never develop the ability to maintain high attention levels during difficult cognitive tasks.

Pollitt believes even more strongly in the role of social factors surrounding malnutrition and places less emphasis on the consequences of specific nutrient deficiencies. Since infantile malnutrition, especially nutritional marasmus, is a condition that develops both as the result of a deficient diet and the action of various adverse biological and social factors, including infections and poor child rearing practices, it is likely to be associated with serious deficits in environmental stimulation and maternal attention and protection. He therefore defines severe protein-calorie deficiency not only as a nutritional condition but as an overall condition of biological and psychological misery and deprivation.

In his review of seven studies of severely malnourished children, Pollitt found that the older the child at the onset of the condition, the better his chances for rehabilitation. Marasmus, the wasting of tissues starting shortly after birth, increasingly debilitates the child and limits his responses to his surroundings. Kwashiorkor occurs later, often after displacement from the breast, so that the infant may have had a more adequate health and experiential start in life. Also, the difference in developmental age at hospitalization and the effects of hospitalization itself on intellectual development or impairment favor the older child's recovery. In reviewing the four studies of nutritional marasmus, Pollitt found the greatest degree of retardation in those studies where the children were 40-50% below the weights normal for their age. Pollitt therefore concluded that the degree of physical retardation also is an important dimension in the prognosis of intellectual development.

The majority of studies reported to date have been concerned with the effects of severe malnutrition, usually protein-calorie malnutrition, on the mental development of children. Implicit in these studies is the hypothesis that the effects of malnutrition will be proportional to the degree of malnutrition experienced. It is possible, however, that there may be a threshold below which malnutrition may permanently adversely affect neurological structures and ultimately behavior; above this level the effects would not be structural but would be transitory or reversible (13). Above this threshold level social, genetic, and environmental factors might be expected to have greater effect. Such a hypothesis could explain the wide variation in results reported in studies from different parts of the world and under different sets of conditions. In his review of human studies, Read has also pointed out the apparently selective effect of malnutrition on different areas of performance, a finding that will have great significance for rehabilitation programs if it is borne out through future research.

In their thorough review of the literature dealing with nutritional deprivation, Birch and Gussow indicate their belief that malnutrition alone does not interfere with learning (14). Rather, they see nutrition in-

teracting with numerous other social, cultural, and health factors. They go on to point out the need for longitudinal data on the prenatal status, delivery, neonatal characteristics, and development of children at nutritional risk. To this we add the critical need for such studies to probe the multiple facets of mental and behavioral development so that appropriate intervention and correctional programs may be designed.

RECOMMENDATIONS FOR ACTION TO IMPROVE THE HEALTH STATUS OF AMERICAN INDIANS AND ALASKA NATIVES

Throughout history, the translation of research findings into action programs has been exceedingly difficult. This issue proved doubly challenging to the combination of researchers, public health specialists, and Native American Representatives who attended the conference upon which this book is based. The Indian Tribal Representatives repeatedly recalled the frequency with which Native American populations have been studied for a variety of purposes; they decried how often they have not received any summary of the research findings nor any recommendations for an action program based on them. It was the consensus of all who participated in the discussions that research results should be translated whenever possible into specific, practical information for use in implementing programs to serve Native Americans. Furthermore, there was similar agreement that research could beneficially be done simultaneously with service programs, both to determine the effectiveness of the program and to obtain new information concerning health and development that would aid in improving future health programs.

The Tribal Representatives met frequently throughout the conference to formulate specific recommendations. As an extension of their desire to have practical interpretation of research findings for use by Native Americans, they recommended that colleges and universities in each part of the country be encouraged to become more closely involved in the problems and needs of nearby communities of Indians and Alaska Natives. They recommended that the Federal government should provide funds to foster and support this type of collaboration, recognizing that Native Americans must be involved in planning, implementing, and evaluating programs influencing their health and future development. The training and hiring of Native Americans to the fullest extent possible in all programs relating to them was seen as a major goal of these collaborative efforts. Another advantage of the association of a university with long-term programs is the assurance of continuity in providing health services and obtaining information on patterns of development and disease and their interactions. Because of professional turnover, long-term grants to universities rather than principal investigators near the population would secure continuing involvement with a specific group. Some medical schools in the southwestern U.S. have already expressed interest in this type of relation.

A major focus for research could well be the determination of specific nutritional problems of different areas as well as the effects of these deficiencies on the health and development of Indian children. Completion of this project on a national basis, including Native Americans of all socioeconomic classes living in urban as well as rural areas, was seen as uniquely valuable. Early translation of these findings into educational programs, emphasizing the minimum nutrients needed and specific remedial measures which might be undertaken (such as use of supplemental foods) was seen as essential. Additional information on the food value of available foods, particularly native foods, would be helpful.

Two main proposals of the Tribal Representatives, the collaboration of Indian groups with universities and the training of Indian health aides, have been underway as pilot projects with apparent success. Queen's University, Kingston, Ontario, has worked with the Canadian government since 1965 to supply pediatric services to Moose Factory, a remote section of the country. Through its service involvement, the medical school began using it as part of its training program, sending residents and medical students under close supervision to the Subarctic for two weeks every two months. The potential for meaningful research combined with the provision of medical care exists in such programs. The training and participation of Native Americans has also been underway and expanding for several years through the IHS. One program includes the training of Community Health Representatives to work on reservations. The training, undertaken at the request of the Indian tribes, includes four weeks of class work and six of field experience to demonstrate concepts of health and disease and to develop skills in home nursing, first aid, nutrition, environmental health and health education. Another program will provide Community Health Aides to 250 Native Alaskan villages.

A wide range of other recommendations was developed by the Tribal Representatives and the others attending the conference. Most of these have been succinctly summarized in the formal recommendations of the Panel on American Indians and Alaska Natives of the White House Conference on Food, Nutrition and Health held in December 1969 (15). Because of their relevance and specificity highlights of these recommendations are summarized below.

The White House Conference on Food, Nutrition and Health

The central and prime recommendation of the panel, which was reiterated in almost every proposal, was the need for involvement by Native Americans in planning, policy and decision making, implementation, and evaluation of all matters relating to nutrition and health in rural and urban populations.

Improvement of the Quality and Quantity of Food: It was strongly recommended that the quality and quantity of food should be improved through Federal food assistance programs, specifically

by transferring the responsibility from the Department of Agriculture to the Department of Health, Education and Welfare. The kinds and quantities of foods distributed in the commodity and supplemental food programs should be selected on the basis of nutritional needs of the population, cultural preferences and available home facilities for food preparation. Packaging should take into consideration the convenience of the recipients and the facilities available for storage.

Enrichment or fortification of commonly used foods distributed or sold on reservations and in Indian and Alaska Native communities should be required and non-enriched products should be excluded. This would assure the availability of such foods as enriched wheat flour and bread, iodized salt, nonfat dry milk with vitamins A and D, enriched rice and cornmeal, cereal with iron, and fruit juices fortified with ascorbic acid. The quality and safety of meat, poultry and dairy products should be improved by establishing or revising regulations for inspection and grading, with adequate provision for enforcement.

Economic assistance should be provided for services such as water and electricity, which are essential for preparation and storage of food. Budgets should be increased to include free breakfasts and lunches for children in non-Federal and non-parochial schools. Food production should be encouraged by financial subsidies and technical and supervisory assistance. The cost of purchased foods should be reduced by eliminating the near monopoly of food suppliers in some areas through the enactment of new laws and enforcement of existing laws. Prices and profits of traders should be regulated and local communities should be encouraged and supported to establish consumer cooperatives.

Protection and Safety of Indigenous Foods: Indigenous foods should be preserved and protected by various legal and programmatic approaches. Hunting and fishing sites should be defended and areas which provide food supplies should be protected and restocked.

Identification and Surveillance of Nutritional Status: Comprehensive nutritional status studies should be conducted, including clinical, biochemical and dietary appraisals as well as determination of cultural, social, and economic factors affecting eating practices. Longitudinal studies of the growth and development of Alaska Natives and Indian children from birth through school age are necessary. All periodic and continuing surveillance studies should be done among groups most vulnerable to malnutrition because of age, physiologic condition, and location. Maximum participation of Indians and Alaska Natives should be assured in the planning, conduct, followup and evaluation of all studies. Local Indians and Alaska Natives should be hired to implement these studies.

Reduction of Disease: Programs are needed immediately to improve the nutritional health of native populations and to reduce vulnerability to infection and their residuals, including gastroenteric and respiratory infections, tuberculosis, and ear infections. Adequate funds are urgently needed to initiate new and to extend existing programs now dealing with these health problems.

Nutrition Education: A comprehensive program of nutrition and health education is essential to prevent and reduce malnutrition and nutrition-related illness in the entire Native population. This program should include a combination of professional nutritionists and trained nutrition aides; Native Americans should be trained and utilized wherever possible.

Food and nutrition education should be a mandatory part of the school curriculum at all levels, incorporating prevailing cultural, social and economic factors affecting food selection. Nutrition education efforts should be coordinated with school food programs. Indian students should be encouraged to pursue careers in foods and nutrition.

Nutritional Problems of Urban and Off-Reservation Indians and Native Alaskans: Federal funds should be provided to carry out nutritional studies and improve the nutritional health of urban and off-reservation Indians and Alaska Natives. Realistic food stamp allowances are necessary for indigent urban Native Americans.

Currently the Bureau of Indian Affairs (BIA) has employment assistance agencies on reservations which should exercise direct responsibility in screening and preparing Indian and Alaska Native relocatees, including thorough medical, physical and psychological examination, employment assistance and accurate practical orientation on urban living. They should continue to exercise direct responsibility for continuous monitoring of the adjustment of Indian relocatees and for arrangements with health personnel for their counseling. The BIA should retain these responsibilities until relocatees and tribal authorities jointly determine to discontinue them.

Establishment of American Indian Council on Hunger and Malnutrition: An American Indian Council on Hunger and Malnutrition should be established and staffed with Native Americans. Its programs should be under the direction of representatives of Alaska Natives, urban Indians, and Indians who live on or off reservations; representatives of affluent and professional Native Americans should specifically be involved in the Council. The Council should seek more detailed information on the extent and causes of hunger and malnutrition and related health problems from local Indian and Alaska Native groups. Further, it should initiate and encourage total Indian and Alaska Native

involvement and participation in services and programs provided by local, state and Federal programs, demanding equal opportunity under law so Native Americans will benefit fully from existing programs.

CONCLUSION

The Conference on Nutrition, Growth and Development of North American Indian Children reviewed the current health and nutritional status of North American Indians and Alaska Natives and the effects of malnutrition on early development. This Conference was unique in bringing together academicians, clinicians and Indians under joint Federal and private sponsorship. Further, it consolidated existing knowledge, reported new findings, and indicated implications for research and service programs. Though the conference discussions were occasionally heated, they led to a broader understanding of the problems of demonstrating the relevance of research findings to action programs.

Developments subsequent to the conference, including the White House Conference on Food, Nutrition and Health, statements by the Administration, introduction of new legislation, support from professional associations, and efforts by Federal agencies have combined to respond to some of the needs and recommendations outlined here. We feel a favorable shift in thinking is occurring that acknowledges the significance of nutrition in early child development and will lead to concerted efforts to prevent and remedy the effects of malnutrition among American Natives and other segments of the U.S. population.

It is critically important that the pace at which these changes are implemented be accelerated. As Kallen has recently emphasized, malnutrition and the conditions associated with it tend to perpetuate a disvalued and dysfunctional group dependency on the rest of society (16). Permitting hunger and malnutrition to co-exist with affluence may create, as well as reflect, attitudes and values among the more affluent that are inconsistant with the ideals of democracy and equality. In this context, the plight of the Native American population reaches out to touch every American citizen. Solutions to these problems similarly become the responsibility of every thoughtful individual. We hope that this volume will help to make these responsibilities clear.

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U. S. GOVERNMENT PRINTING OFFICE : 1972 OL - 452-750